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RELATIVE VALUES OF DRAINED AND UNDRAINED BOTTOMLAND IN ILLINOIS[1]

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An increasing number of marsh and lake owners in the United States are becoming aware of the economic value of wildlife resources on their properties. Many obtain satisfactory dividends by renting boats and cottages to fishermen; by leasing their properties for duck hunting or operating daily-fee hunting clubs; or by trapping or selling fur-trapping rights on either a cash or crop rental basis.

Despite the recognized value of wildlife land in many places, continued unwise drainage and "flood control" projects by private owners and governmental agencies indicate that more factual information on the subject should be available to all groups and individuals involved. Because the records and information now available are inadequate, it often is necessary for wildlife technicians and conservationists to speak about values of drained and undrained land in such general terms as to have little weight.

An important objective in wildlife work should be to compile figures on the relative values of undrained and drained areas in the principal geographic regions and various habitat types of the United States and Canada. This paper presents figures for one region, central Illinois, and one habitat, overflow bottomland, and suggests how greater income might have been obtained under maximum management from the wildlife resources of one marsh and water area, Rice Lake.

Farmers usually manage arable lands more efficiently than do most owners of wild lands, probably because more is known about obtaining maximum yields from arable lands and because managing production and harvest on wild lands is apparently more complex. Greater information about wild lands will tend to minimize the seeming complexity of the problems presented.

VALUE AND YIELD OF MUSKRAT MARSHES

According to Storer (1937), at the beginning of the century, owners of a few eastern marshlands already recog-

[1] The following persons contributed information, criticism, or valuable advice for this paper: G. P. Wilson, U. G. Orendorff Land Co., Canton; G. R. Barton, Duck Island Farm, Canton; C. L. Eaton, Havana Loan Co.; Roberts Mann, Forest Preserve District of Cook County; W. L. McAtee and Richard Griffith, U. S. Fish and Wildlife Service, Chicago, and Leo Borgelt, U. S. Fish and Wildlife Service, Havana; C. L. Stewart, University of Illinois; Hugh B. Wycoff and F. X. Lueth, Illinois Department of Conservation; L. E. Yeager, R. E. Yeatter and G. W. Bennett, Illinois Natural History Survey. James S. Ayars, technical editor of the Survey, gave material help in preparing the manuscript.

nized the value of muskrats and treated their marshes as preserves or "wild farms," from which they obtained an annual yield. The rise in muskrat prices during and after World War I brought widespread attention to muskrat farming. Rearing the animals was tried in enclosures ranging from small wire pens to ponds and marshes enclosed by animal-tight fences. Most of those ventures ended in failure for, through the years, the price of muskrat pelts did not compensate for the high costs involved.

While pen-raising for fur proved uneconomical, the natural management of muskrat marshes has been profitable in many sections of the continent. Bailey (1937) said of Maryland marshes: "The muskrat industry is recognized as one of the most important resources of the state, and good muskrat marshes are as valuable as any farm land. . . . Three or four muskrats per acre is about the average yield, but on good marsh, well managed, six or eight per acre is not an unusual crop." In Delaware, Stearns, MacCreary and Daigh (1940) state that: "For years, a large proportion of the cash income of farmers in that part of the State (Delaware River and Bay) has been derived the sale of muskrat hides and meat. The muskrat has long been recognized, therefore, as one of the most important of the natural resources of Delaware, and good muskrat marshes are as valuable as any farm land."

The trapping of muskrats is a large business in Louisiana. A number of companies and individuals own or control wide areas of coastal marshland on which many muskrats are trapped yearly. O'Neil (1942) reported that in 1940–41 about 5,500,000 muskrats were taken in Louisiana. He stated (1943) that there are about 6,000,000 acres of trapping land in the coastal marshes and deep swamps in the southern part of the state. His 1942 figures reveal 473,590 muskrats taken from 132,450 acres of trapping marsh, or 3.58 per acre. These coastal marshes are managed primarily for muskrats, secondarily for waterfowl hunting, and sometimes for cattle grazing.

Of coastal marshes in southeastern Texas, Lay (1939) wrote: "Since the World War days when muskrat pelts increased in value from less than 10 cents to more than $1.00, coastal cattlemen, who own most of the marshes, have gradually changed their attitude toward the muskrat. Today the animals which tunnel the marsh making walking difficult are in good repute generally because they have proven themselves a valuable crop. Most ranchers who have good marsh admit that for several years sales of furs have yielded more than cattle, and even more than oil wells under present operation. An annual crop of 10 muskrat pelts to the acre is not uncommon. With last winter's average price of 60 to 70 cents per pelt, the landowner's net return was better than $3.00 per acre from a crop which cost nothing to produce." Lay calculated that about 342,958 pelts were taken from less than 233,000 acres and believes that if all marshes in the area could be made to produce, as did those under proper management, the annual crop would be worth $2,000,000 at 60 to 70 cents per pelt.

Yeager (MS) found that the average

annual catch in the Glacial Lakes region of northern Illinois in 1938–40 was 2.37 pelts per acre; at the 1941 average of $1.40 a pelt this would amount to $3.32 per acre of marsh.

The Province of Manitoba in 1937 began to improve 540,000 acres along the Saskatchewan River near The Pas. In discussing the Summerberry Unit of 140,000 acres in that project, Presnall (1942) stated: "The topography of the area permits control of water levels with three sets of intake and outlet gates. During flood periods, gates are set to secure a maximum depth of about four feet over the marshes after which intakes are closed to prevent loss of water as the river level drops." From 1937 until essential improvements were finished and trapping started in 1940, Presnall reported that the muskrats increased from 19,755 to 230,135. In the spring of 1940 about 120,000 pelts were taken and sold at an average of $1.32 each. In 1941, 191,000 were taken, which averaged $1.88 apiece. The income averaged $2.56 per acre for the entire area, which consisted of about 60 per cent land.

Hewitt (1942) has described the profitable conversion of a farm into a marsh in southern Ontario. In 1912 a property of 1,600 acres east of Detroit was provided with ditches and levees, but only 250 acres could be farmed profitably because high water levels delayed operations in the spring and the expense of controlling the water was too great. In 1929 the tract was converted into a marsh. With flooding, natural vegetation rapidly developed on 1,250 acres that soon became covered by cattails, bulrushes, and submerged vegetation. Two pumps maintained a constant water level during the summer when the river level was from 2 to 2½ feet below that of the marsh. Muskrat trapping began in 1930 and 575 pelts taken, an average of 0.46 per acre. The numbers increased rapidly and by 1942, 8,191 were taken, nearly 7 per acre, and sold for an average of $2.15 each, a gross return of about $14.00 per acre. Duck hunting furnished another major source of income, and minor profits accrued from the sale of muskrat meat and fish, and of sport fishing privileges in the spring. In the winters of 1935–36 and 1937–38, commercial fishermen seined the marsh on a profit-sharing basis, the fish selling for $1,900 the first season and $1,500 the second.

None of the papers cited, from which information was obtained on the wildlife revenue of marshes, were written primarily to show the values of wildlife. Most of them dealt with marsh management, and chiefly of muskrats. Generally the revenue had to be calculated by the present writer, and the basic information is incomplete, because duck hunting and fishing undoubtedly brought additional revenue on many of them.

An increasing number of landowners recognize the possibilities of revenue from the wildlife of aquatic habitats, but all too many are still unaware of the potential worth of such areas. Many marshes and other water areas are still being drained, some are misused, and unprofitable drained areas continue to be farmed—all evidence that wildlife workers need to conduct an intensive campaign of research, demonstration, and education on the subject.

WILDLIFE RESOURCES ON BOTTOMLAND LAKES

As in many other states, thousands of acres have been drained in Illinois and about half of the bottomlands of the Illinois River Valley are in levee and drainage districts. Originally about one-third of the area in these districts was covered by bottomland lakes and the remainder either cultivated or in timber. Of the present unleveed bottomlands, about 90 per cent are owned by duck clubs or individuals who derive income from duck hunting, but not all of these lands are used for duck hunting because timber and cultivated fields comprise about 65 per cent of the area. The fields do not produce a full crop ever year, since floods cause some loss in about two years of every five.

One 90-acre cultivated field near Rice Lake produced an annual net of $3.79 per acre from 1931 through 1942, principally from corn. As a 6 per cent return on the investment, the value of this field was $63.17 per acre. Another field of 40 acres yielded an annual net return of $2.37 per acre, 1931–1936; on the same basis this had a value of $39.50 per acre.

Most marshes and bodies of water in the Illinois River Valley are used extensively for duck hunting, but sport fishing also is popular on 11 areas, aggregating 25,000 acres. These are Goose Pond, Lake Senachwine, Douglas Lake and Rice Pond, Upper Peoria Lake, Spring Lake, Beebe Lake, Rice Lake, Lake Chautauqua, Patterson Bay, Stewart Lake, and Meredosia Bay. One or more private boat liveries provide transportation for fishermen on each of the areas.

Commercial fishing has long been an important industry in the Illinois River Valley. In 1908, the Illinois River and its lakes produced more than 10 per cent of the commercial freshwater fish taken in the United States (Alvord and Burdick, 1919)—23,896,000 pounds, which, at $0.0302 per pound, returned $721,000.00 to fishermen. According to Thompson (1931) the catch dropped to 4,000,000 pounds in 1921, when fishing conditions were poor, but rose to 10,500,000 pounds in 1922, and remained near that level until 1930. Thompson attributed the sharp decline in yield from the peak of 1908 to pollution and to the draining and leveeing large sections of the valley. Between 1930 and 1940, the catch of commercial fish declined to between 5,000,000 and 6,000,000 pounds annually, due largely to low water levels, which greatly reduced the water surface in the valley. The average wholesale price of undressed fish per pound at the Havana markets, 1928–44, was $0.045 for carp and $0.08 for buffalo. Carp then comprised about 75 per cent of the catch. The industry brought from $150,000 to $250,000 annually to the wholesale fish markets; this was during depression years, when money was especially needed.

There is commercial fishing on about 50,000 acres of lake waters, indicating, at $200,000 per year, an annual harvest of $4.00 worth of fish per acre. D. H. Thompson believes that a harvest of 200 pounds annually per acre could be obtained if the lakes were fished intensively. At the conservative price of $0.05 per pound, this would yield $10.00 per acre. On many areas, commercial fishermen pay the landowners 40 to 50 per cent of the value of the catch for

fishing privileges. It is logical to assume, therefore, that owners of well-managed bottomland lakes could receive up to $5.00 per acre for commercial fishing rights.

Muskrats are trapped in fair numbers throughout the Illinois River valley, the catch depending on the quality of the environment. Bellrose and Brown (1941) showed the importance to muskrats of stabilized water levels and certain types of vegetation. An enumeration of lodges in the winter of 1939–40 showed the highest muskrat population per acre of emergent vegetation at Lake Chautauqua, followed by Rice Lake, Cuba Island, Goose Pond, the Douglas Lake area, and others. In 1940–41, densest populations were on the Douglas Lake area, Lake Chautauqua, and Rice Lake. Minks and raccoons, as well as muskrats, have furnished much income to local trappers.

Duck hunting probably results in an exchange of several hundred thousand dollars in the valley each year. Private clubs spend much in the maintenance and improvement of their properties and in salaries and wages to caretakers and guides.

In recent years proprietors of day shooting places have charged duck hunters from $5.00 to $15.00 each per day. The owner of one place north of Havana charged $25.00 per day for the rights on 5 acres; he received $560 in 1943 and $1,030 in 1944, and, in addition, he and his friends enjoyed free hunting about one day a week. The owner of a 100-acre daily-fee club near Havana received $1,215 from hunters. An 80-acre river bulrush marsh on Swan Lake leased for $1,800 in 1943 and $2,200 in 1944. About 200 acres of water and land adjacent to Rice Lake, near Banner, leased for $1,000 in 1943 and $1,200 in 1944.

This general account of the economically important wildlife resources of the Illinois River Valley affords a criterion for comparing the wildlife assets of Rice Lake with those of other areas in the valley. Rice Lake is among the better muskrat producing lakes along the Illinois River but far below many other waters in yield of commercial fish. It has an average value for sport fishing, and for duck hunting.

INCOME FROM RICE LAKE

Rice Lake (Fig. 1) contains about 1,034 acres of water and marsh. It is midway between Havana and Peoria and more than a mile from the Illinois River, being between the valley bluff on the west and Duck Island on the east. Duck Island is a glacial gravel deposit, ½ by 3 miles, that rises about 15 feet above the bottomland. Between it and the river channel lies Beebe Lake separated from the river by a natural levee. A narrow channel connects the upper ends of Beebe and Rice lakes. Man-made levees to the north and south isolate Rice Lake, so that (except in extreme floods) the Illinois River influences it only through the narrow channel connecting with Beebe Lake.

Rice Lake is shallow; the open water areas average about 2 feet in depth when the Illinois River is at a 9.2-foot stage at Havana and at a higher stage river water enters the lake. The river stage there has varied from 5.0 to 27.0 feet in the past 10 years (Fig. 2). The water level generally rises in spring, subsides during midsummer, and frequently rises in autumn. At river stages

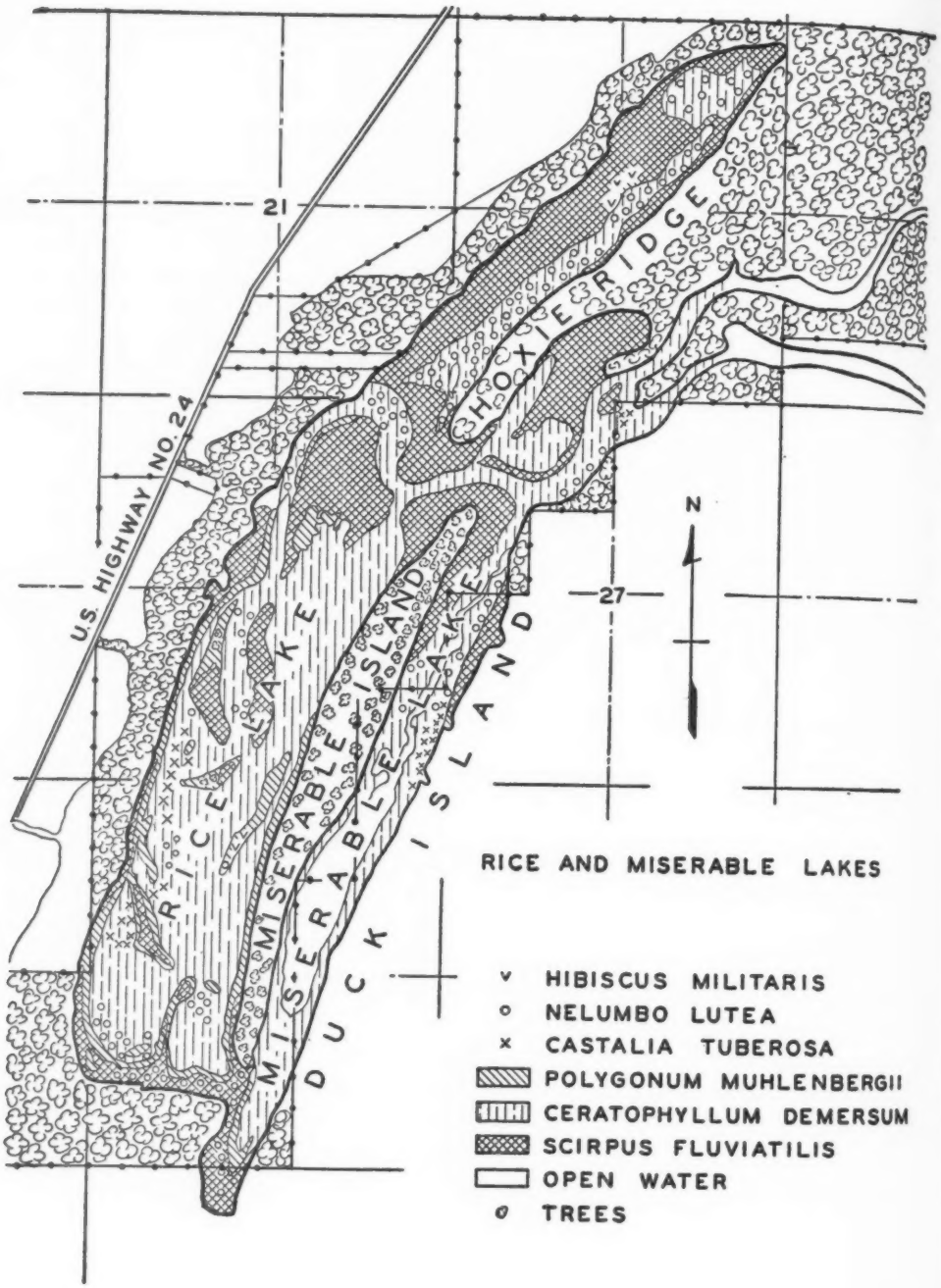

Fig. 1. Rice Lake and contiguous areas in October 1943, with distribution of principal marsh and aquatic plants, bottomland timber, and cultivated fields. Average depth of water in the beds of coontail, 20 inches; among river bulrush, 4 inches. The dash and dot line marks boundary of land purchased by Illinois Department of Conservation in 1943.

below 9.2 feet, the level in Rice Lake usually remains fairly constant, save for local runoff and evaporation. A fluctuation of over 12 inches is uncommon, but in 1934 seepage and evaporation removed all the water from the lake basin.

Because water levels are more nearly stable at Rice Lake than in most other local lakes and because this lake has a shallow basin, it contains a greater development of marsh and aquatic plants (Fig. 1). Notable are the extensive beds of river bulrush (*Scirpus fluviatilis*), American lotus (*Nelumbo lutea*) and coontail (*Ceratophyllum demersum*).

The U. G. Orendorff Company owned the lake until the autumn of 1943, when it was bought by the Illinois Department of Conservation. In addition to the lake (1,034 acres), the Department purchased 968 acres of timber-land and 235 acres of adjoining agricultural land. Records are available of the income the company received from the wildlife resources of the lake, 1937–43 (Table 1).[2]

DUCK HUNTING

Duck hunting brought the greatest return, an annual average of $2,114.17 paid by clubs and individuals for leases. Three groups of individuals, forming clubs, were the principal leaseholders each year. Income was less in 1937 and 1938 largely because of shorter hunting seasons.

TABLE 1.—INCOME FROM WILDLIFE RESOURCES OF RICE LAKE, ILLINOIS, 1937–42. (Records of U. G. Orendorff Company.)

Year	Duck hunting	Furbearer trapping	Sport fishing	Totals
1937	$1,400.00	$ 511.40	$ 316.30	$2,227.70
1938	1,400.00	909.80	1,192.00	3,501.80
1939	2,400.00	802.50	600.44	3,802.94
1940	2,060.00	1,029.50	0.00	3,089.50
1941	2,725.00	1,106.75	0.00	3,831.75
1942	2,700.00	912.50	253.21	3,865.71
Averages	$2,114.17	$ 878.74	$ 393.66	$3,386.57

TABLE 2.—DUCKS KILLED AT HUNTING CLUBS ON RICE LAKE, 1938–42.

Year	*Number*	*Comments*
1938	4,123	Excellent growth of coontail on 172 acres; many widgeon and gadwall killed.
1939	2,150	Low water; only 99 acres of coontail.
1940	1,735	American lotus over 317 acres; 3 acres coontail; little open water.
1941	3,896	High water flooded cornfields during open season; many mallards killed.
1942	1,705	Lotus covered most of lake; little coontail.
Average	2,722	

The average annual kill of 2,722 ducks (Table 2) indicates that the rentals for duck hunting were somewhat low. Local marsh owners generally value each duck as worth at least $1.00 for rental purposes. Wildlife technicans estimate that each costs the hunter about $5.00, including transportation,

[2] Made available by G. P. Wilson, Secretary U. G. Orendorff Company.

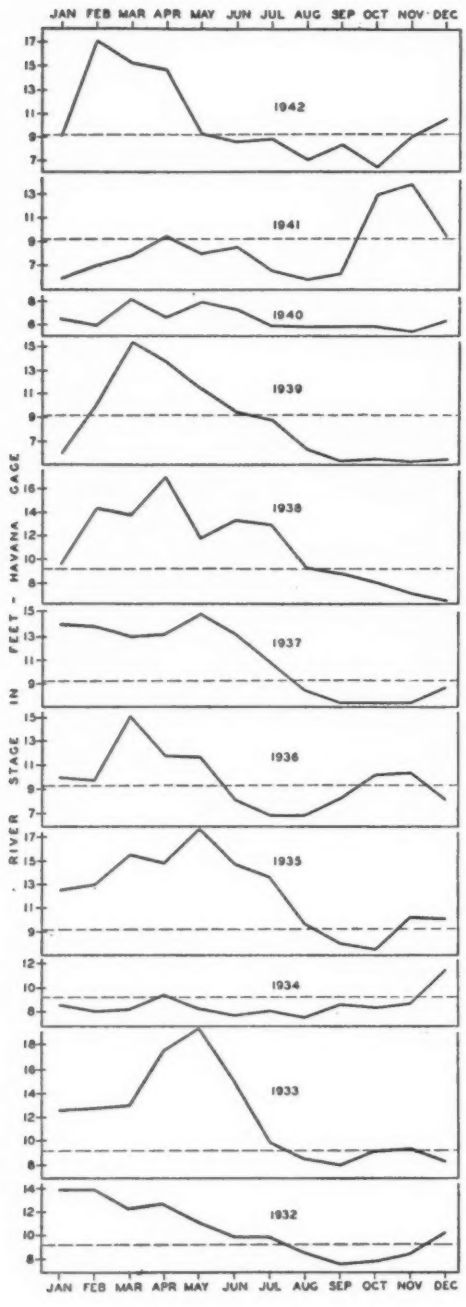

Fig. 2. Seasonal fluctuation of water levels in Illinois River at Havana, 1932–42. The broken line indicates 9.2 feet on the Havana gauge. Above that stage, water from the river enters Rice Lake; below that stage, fluctuations in river level have no major influence on the level of the lake.

lodging, meals, clothing, guns, shells, etc.

A large concentration of widgeons and gadwalls, attracted by extensive beds of coontail, made possible the high kill in 1938. Low water levels (Fig. 2) during 1939, 1940, and 1942, attended by growth of several hundred acres of American lotus, resulted in reduced duck kills in those years.

FURBEARER TRAPPING

In 1937–42, the Company averaged $878.74 yearly from sale of pelts (Table 1). Trappers are assumed to have received a like sum, since their share was 50 per cent of the catch, but several turned in only part of their catches. The greatest muskrat catch in the records was 2,183, yet local reports indicate that at least 3,000 muskrats have been taken in several recent years. In 1942-43, only 919 were recorded, yet an authoritative source states that about 3,000 muskrats were caught in that season. Poaching was especially bad, as the superintendent of the lake was absent. Muskrats furnished more than 95 per cent of the fur animal income, 9,020 being trapped in 1937–42, when only 32 raccoons and 25 minks were reported. The reported average yearly catch over the 6 years was 1,505 muskrats, a minimum of three per acre of marsh or 1.5 pelts per acre for the entire lake.

River bulrush is the staple food of

Rice Lake muskrats, but pickerelweed (*Pontederia cordata*) is their preferred food. In most years, river bulrush covers about 450 acres of the area. Other species of marsh plants—marsh smartweed (*Polygonum Muhlenbergii*), wild rice (*Zizania aquatica*), and pickerelweed—sometimes occupy an additional 50 acres.

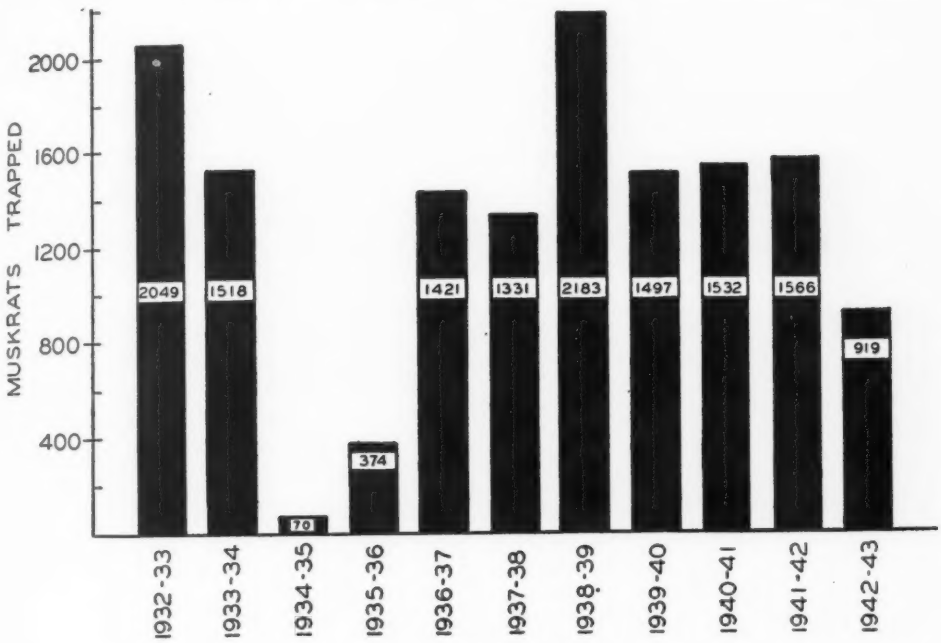

Fig. 3. Number of muskrats trapped annually on Rice Lake (records of U. G. Orendorff Co.).

Seldom is the entire marsh area available to muskrats. When the river stage is at 9.2 feet, there is little water in the river bulrush beds of Rice Lake, and the animals are forced to build their houses in the deeper water around the edges of the bulrush beds, reducing the area suitable for the population. Even in years when American lotus covered most of the lake and most of the houses necessarily were located in that zone, muskrats fed on river bulrush more extensively than on lotus.

FISH

Income from sport fishing came from rental of boats at 75 cents per day and 25 per cent of this was the caretaker's commission. The company's net income averaged $393.66 a year (Table 1). If the $688.82 obtained from boat rentals in 1943 before purchase of the area by the State were included, the average would have been $435.82 a year.

Within the years specified, the amount from boat rentals each year varied from nothing to $1,192, primarily because of differences in plant growth. Low water levels resulted in heavy growths of coontail and American lotus which reduced or prohibited fish-

ing by making it difficult to cast or to immerse a hook and line. In 1944, owners of a boat yard on nearby Beebe Lake received $2,993 from renting boats to hook-and-line fishermen.

Commercial fishing has produced little revenue at Rice Lake in recent years. In most years, particularly when high water prevailed during the spring, there were many rough fish in the lake, but no serious attempt was made to harvest them. Rough fish populations, however, have never been as large in Rice Lake as in most other bottomland lakes. Owners of Beebe Lake received $3,725 for rough fish taken by commercial fishermen who seined under the ice in the winter of 1943–44.

MANAGEMENT OF WATER LEVELS

Unlike most other bottomland lakes along the Illinois River, Rice Lake is not contiguous to the river. Because of its isolation and the natural and artificial barriers around much of the lake, it would be possible to control the water levels partly by a dam across the Narrows from Hoxie Ridge to the head of Duck Island. This dam could be constructed for an estimated $3,819. It would retain part of the spring rise and the local runoff, thereby increasing the water depth 2 to 3 feet over the lake level now prevailing during drought periods. The potential effects of such change on the wildlife resources and income can be evaluated by analysis of the records.

DUCK HUNTING

The kill of ducks was greatest in 1938 when (Fig. 2) the lake depth averaged 5 to 6 feet during the growing season (May-July) of aquatic plants. The comparatively high water reduced the growth of river bulrush and produced the greatest abundance of coontail and marsh smartweed known in the years of this study. The growth of these duck food plants attracted especially large numbers of widgeons and gadwalls.

In 1939, the water depth averaged 3 to 4 feet during the growing season, reducing the coontail about 40 per cent and almost doubled the river bulrush. The duck kill dropped 48 per cent.

In 1940 the river did not influence depth of water in the lake which was about 2 feet throughout the year. American lotus increased from 64.0 to 317.5 acres, and shaded out most of the coontail, which was reduced from 99.0 to 2.9 acres. The duck kill, again declined, this time, about 20 per cent from the 1939 figure.

In 1941 water levels again were low during the growing season and lotus almost covered the lake. Little native duck food was produced. The water level rose 7 feet in the autumn, flooding adjacent bottomland cornfields, which enticed mallards by the thousands. This resulted in a duck kill 125 per cent of that in 1940.

Early in the spring of 1943, the average water depth was about 8 feet but during much of the growing season only 2 to 3 feet deep. About three-fourths of the open water was covered by American lotus. Coontail was more abundant than in 1941 or 1942, but other natural food conditions were not favorable, and only 1,705 ducks were killed.

A definite correlation, therefore, exists between water depth and the abundance of duck food plants, and between the food supply and kill of ducks

at Rice Lake. The proposed dam, by providing deeper water, would increase the coontail and marsh smartweed and decrease the American lotus and river bulrush. Higher water levels would permit hunters to shoot over sections of the marsh not now available to either hunters or ducks. The proposed dam might increase the annual income from duck hunting by $400 to $800.

MUSKRAT TRAPPING

The number of muskrats taken by trappers from year to year, does not adequately reflect fluctuations in the population, often being influenced by ice conditions. During seasons when the freeze-up was late, larger proportions of the population were harvested than when early. In 1934–35 and 1935–36, a low population was responsible for the poor catches. During the summer of 1934, Rice Lake dried completely from the most prolonged drought on record. Even when the area was submerged by 5 feet of water in the following December and January, only 70 muskrats were caught.

In 1935, floods lasted during most of the breeding season and prevented the low population from making much of a recovery; only 374 muskrats were trapped in the 1935–36 season. In 1936 water levels were not very high during the breeding season but during the trapping season were high enough to drown trapped animals; this prevented many "wring-offs," or escapes, and increased the take to 1,421 muskrats.

When the water depth was suitable, the river bulrush beds revealed a greater density of muskrat houses than any other type of vegetation. In most years, however, the water receded from large sections of these beds by the time lodge construction commenced in September. In September 1941, the water on the river bulrush beds averaged about 12 inches deep and a survey then showed most of the muskrat lodges to be situated in this zone; there was an increase of at least 25 per cent in the total number of lodges over the previous year. Despite a sharp rise in the water during October, which caused considerable losses among late season litters and made trapping difficult, a few more muskrats were caught in 1941–42 than in the previous season.

Both low water and floods are detrimental to the muskrats and to the trapping of them, as shown by Bellrose and Brown (1941) and Bellrose and Low (1943). The proposed dam would not prevent great floods from invading the lake basin, but would create a normally higher water level, favor muskrat production and trapping, and probably would add 200 to 800 muskrats to the annual catch.

SPORT FISHING

The growth of aquatic vegetation inhibited and, in two years (1940, 1941), prohibited hook-and-line fishing at Rice Lake as previously mentioned. The area invaded by aquatic plants was determined largely by the water depth during the growing season. When from 2 to 3 feet deep in this period, American lotus was permitted to occupy almost the entire lake in both years. Coontail occurred among the lotus plants and in the few open areas.

In 1937 the lake was about 6 feet deep through June and 2 feet deep by August. In that year the Company received $316.30 from boat rentals.

Levels in the following year were similar, except that the water remained about 6 feet deep through July and provided an additional month of good fishing. Indeed, fishing was above average during the entire season and boat rentals netted the Company $1,192. In 1939, the depth was 4 to 6 feet in April and May, receding to a little more than 2 feet by June. The subsequent low water resulted in reduced fishing and income—only $600.44. In 1942 the water levels dropped by May, a month earlier than in 1939 and two months earlier than in 1938. The decreased fishing was reflected by boat rentals totaling only $253.21. Despite gasolene rationing and reduced recreational time, boat rentals netted $688.82 in 1943, when the water remained high through July.

The proposed dam to raise the water 2 feet above the prevailing midsummer level, would greatly prolong the usefulness of the lake for hook-and-line fishing; past records would indicate $200 to $700 more annual revenue from boat rentals.

The dam should be an economically sound investment and worthwhile as a management measure. Potentially, it would increase the income from duck hunting, trapping and fishing by $1,000 to $2,300 annually, depending on the degree of water level afforded, which would be determined to some extent by river levels.

DRAINAGE DISTRICTS

Prior to 1904, large areas of the higher, secondary bottoms of the Illinois River Valley were under cultivation. Most of the lower, primary bottoms were covered by lakes and extensive timber tracts. Leveeing of both primary and secondary bottoms was begun before 1900, and by 1913 about half of the present levee and drainage districts had been formed.

Under Illinois laws, drainage districts are quasi-governmental organizations that possess limited powers to contract, construct, and finance needed drainage works. Enabling laws permit mutually interested landowners to organize drainage districts under concurrent jurisdiction of county, circuit, and, in some instances, justice courts. Two distinct laws were enacted, the Drainage and Levee Act of 1879 and the Farm Drainage Act of 1885, to serve the two distinct types of Illinois drainage: the subsurface tile and open ditch, characteristic of the corn belt; and the levee and ditch, prevalent in the bottomlands near the major rivers. The type under the first act, of projects involving levees, is by far the more expensive, in both capital investment and operating costs.

Most of the levee districts are near the Illinois and Mississippi rivers. In 1937 there were 36 active levee districts in the Illinois River Valley involving about 192,000 acres or about 50 per cent of the flood plain. On the Illinois side of the Mississippi River, there were 36 districts, about 500,000 acres or 85 per cent of the bottomland.

To drain land within a leveed area, ditches are dug and pumping plants often provided to pass excess water from the ditches over the levee to the adjacent stream. Most levee districts in the Illinois River Valley have pumping plants. Twelve of those on the Illinois side of the Mississippi River have pumping plants; most of them being north of Quincy. The other levee

districts depend upon gravity drainage to remove excess water.

The capital investment by a district is represented by the initial value of land and by construction assessments for building levees and pumping plants, dredging ditches, and other drainage works. Most such districts have had to make additional construction assessments to expand the initial work and to repair flood damage. Operating expenses are obtained from annual benefit assessments.

studies by various state and federal agencies, complete records of money expended for construction and maintenance and the income received from agricultural products are not available.

In an effort to portray the expenses incurred and returns received from leveed bottomland, the writer has selected those levee districts nearest Rice Lake in Fulton County for which the most nearly complete data are available. The principal construction expenditures for four districts are shown in

TABLE 3.—PRINCIPAL EXPENDITURES PER ASSESSED ACRE OF LAND IN FOUR LEVEE AND DRAINAGE DISTRICTS NEAR RICE LAKE, FULTON COUNTY, ILLINOIS.

District	Organized	Acres	Construction assessments to 1938		Federal expenditures on levees, 1938–43		Flood damage to farm improvements, to 1944		Totals	
			Total	Per acre	Total	Per acre	Total	Per acre	Gross	Per acre
Banner Special	1910	4,279	$ 977,886	$228.53	$273,700	$63.96	$34,700	$ 8.11	$1,286,286	$300.60
East Liverpool	1916	2,765	384,594	139.09	207,500	75.04	20,250	7.32	612,344	221.46
Liverpool	1916–23	3,024	272,860	90.23	117,400	38.82	—	—	390,260	129.05
West Matanzas	1913	2,678	422,161	157.64	27,900	10.42	42,600[a]	15.91	492,661	183.97
Totals		12,746	$2,057,501		$626,500		$97,550		$2,781,551	
Averages				$161.42		$49.15		$ 7.65		$218.23

Sources: Illinois Tax Commission, 1941
Mulvihill and Cornish, 1929
Chicago Office, Corps of Engineers, U. S. Army, 1944

[a] Damage in 1926 flood estimated by Mulvihill and Cornish (1929) at $21,300; that from 1943 flood assumed to be the same.

To finance construction, Illinois levee districts could and frequently did borrow up to 90 per cent of the total assessments. Generally bonds were issued for about 70 per cent of the construction assessments and the district paid the remainder from its own funds. Bonds were usually amortized over 10 years (extremes, 2 to 33 years). Underwriting fees and expenses usually approximated 2 per cent of the loan, and the standard interest rate was 6 per cent.

It is beyond this paper to review the financial condition of levee and drainage districts in Illinois. Despite many

Table 3. The initial and subsequent construction assessments for levee and drainage works averaged $161.42 per assessed acre. Flooding of three of the four districts in 1926 and of one again in 1943 resulted in damage to farm buildings and other improvements that averaged $7.65 on a per assessed acre basis for all four.

From 1938 through 1943, the Corps of Engineers, U. S. Army, through private contractors, rebuilt and improved levees in three districts: Liverpool, East Liverpool, and Banner Special. All construction costs, amounting

to $598,600, were borne by the federal government. Following the 1943 flood, levees of the West Matanzas District were repaired at a cost of $27,900. These federal expenditures amounted to $49.15 per assessed acre in the four districts. The work was done under the Flood Control Act of June 22, 1936.

Most other levee districts along the Illinois and Mississippi rivers have received similar federal aid. In addition, the state in 1926 provided $1,500,000 for levee repairs along the Illinois and Mississippi rivers (Illinois Tax Commission, 1941).

TABLE 4.—ANNUAL EXPENSES PER ACRE OF ASSESSED DRAINAGE DISTRICT LAND, 1937–42, IN FOUR LEVEE AND DRAINAGE DISTRICTS NEAR RICE LAKE, FULTON COUNTY, ILLINOIS.

Maintenance of levees	$0.35
Maintenance of ditches	0.40
Pumping costs	1.50
Miscellaneous (commissioner, engineer, attorney and court costs)	0.50
General tax	1.00
Interest on bonded indebtedness ($25 at 4%)	1.00
Maintenance and depreciation of buildings, fences, etc.	1.25
Total	$6.00

Other government agencies have provided huge sums to aid levee and drainage districts. The Reconstruction Finance Corporation loaned $3,000,000 to Illinois levee and drainage districts, of which $233,048 went to the four districts under discussion. The Works Progress Administration expended $9,749,969 in drainage districts throughout the state (Illinois Tax Commission, 1941). There were five Civilian Conservation Corps camps engaged in drainage work; one at Havana in levee districts in the central section of the Illinois River Valley. Up to 1937, when work was still in progress, $394,181 had been charged by this camp against work in the four districts named, or $30.92 per assessed acre. In calculating the value of levee district land, CCC expenditures are not included.

The operation, minor maintenance, and certain other annual expenses per assessed acre for these districts are given in Table 4. The annual benefit tax, mentioned before, covering operation of the pumping plant and other minor expenses affecting leveed land, amounts in most local districts to $2.50 per assessed acre.

Has the net income from arable land in these districts been commensurate with the expense for construction, maintenance, and operation? Because of difficulty in estimating the expenses of the tenant farmer each year, the expense and the income of the landowner, as in the case of Rice Lake, have been used in determining the answer.

The year by year income and expenditures per assessed acre for a landowner in a typical levee and drainage district of Fulton County from its formation through 1944 are given in Table 5. The data have been calculated for the West Matanzas District which has the most nearly complete records over the longest period of years (Illinois Tax Commission, 1941).

Over the 29 year period, a landowner would have averaged an annual cash return of about $13.72 per assessed acre. Fifty bushels of corn per cultivated acre is the average annual yield (Mulvihill and Cornish, 1929). To maintain this yield it is necessary to rotate corn with other crops. Generally about one-fourth of the land is devoted to winter wheat, which yields a lower cash

TABLE 5.—INCOME AND EXPENSE OF LANDOWNER PER ASSESSED ACRE IN TYPICAL CENTRAL ILLINOIS RIVER LEVEE AND DRAINAGE DISTRICT FROM ORGANIZATION, 1916, THROUGH 1944.

Year	Price per bushel of corn[a]	Gross income to landowner[b]	Construction charges and interest[c]	Annual benefit charges[c]	State and county taxes; maintenance and depreciation	Total expenses to landowner	Net income
1916	$1.11	$ 22.20	$ 3.48	$ 0.90	$ 3.00	$ 7.38	$ 14.82
1917	1.30	26.00	3.77	0.90	3.00	7.67	18.33
1918	1.42	28.40	3.77	0.90	3.00	7.67	20.73
1919	1.47	29.40	3.77	0.90	3.00	7.67	21.73
1920	0.58	11.60	3.77	0.90	3.00	7.67	3.93
1921	0.47	9.40	4.88	2.50	3.00	10.38	−0.98
1922	0.69	13.80	8.68	2.50	3.00	14.18	−0.38
1923	0.78	15.60	8.42	2.50	3.00	13.92	1.68
1924	1.02	20.40	6.16	2.50	3.00	11.66	8.74
1925	0.64	12.80	8.63	2.50	3.00	14.13	−1.33
1926	0.69	0.00[d]	5.02	2.50	3.00	10.52	−10.52
1927	0.85	0.00[d]	4.91	2.50	3.00	10.41	−10.41
1928	0.80	16.00	4.91	2.50	3.00	10.41	5.58
1929	0.77	15.40	5.33	2.50	3.00	10.83	4.57
1930	0.54	10.80	5.58	2.50	3.00	11.08	−0.28
1931	0.24	4.80	5.21	2.50	3.00	10.71	−5.91
1932	0.26	5.20	4.31	2.50	3.00	9.81	−4.61
1933	0.50	10.00	4.31	2.50	3.00	9.81	0.19
1934	0.85	17.00	4.31	2.50	3.00	9.81	7.19
1935	0.66	13.20	4.31	2.50	3.00	9.81	3.39
1936	1.09	21.80	4.31	—	3.00	7.31	14.49
1937	0.46	9.20	2.25[e]	2.50	3.00	7.75	1.45
1938	0.45	9.00	2.25	2.50	3.00	7.75	1.25
1939	0.51	10.20	2.25	2.50	3.00	7.75	2.45
1940	0.61	12.20	2.25	2.50	3.00	7.75	4.45
1941	0.74	14.80	2.25	2.50	3.00	7.75	7.05
1942	0.89	17.80	2.25	2.50	3.00	7.75	10.05
1943	1.04	0.00[d]	2.25	2.50	3.00	7.75	−7.75
1944	1.04	20.80	2.25	2.50	3.00	7.75	13.05
Totals	—	$397.80	$125.84	$62.00	$87.00	$274.84	$122.95
Yearly average	—	$ 13.72	$ 4.34	$ 2.14	$ 3.00	$ 9.48	$ 4.24

[a] Data from Illinois Co-operative Crop Reporting Service.

[b] Calculated as follows: average yield per cultivated acre, 50 bushels; other less profitable crops rotated every 4 years to maintain this yield; about 10% of acreage uncultivable; these two factors would lower cash return to equal about 40 bushels of corn per acre of which landowner receives half.

[c] Data for West Matanzas Drainage District, 1916–36; see Illinois Tax Commission, 1941.

[d] Flooded, no crop.

[e] Debt and interest rate reduced by refinancing outstanding bonds by Reconstruction Finance Corporation.

return than corn. About one-tenth is uncultivated because of buildings, ditches, road rights-of-way, and waste ground. After making deductions for the lower yield of crops other than corn and for land that cannot be cropped, the cash return is calculated to be equivalent to 40 bushels of corn annually per assessed acre; of this the landowner receives half. Construction and interest charges amount to about $4.34 annually per assessed acre. It is estimated (Illinois Tax Commission, 1941) for other districts (West Matanzas not

given) that interest payments over the period of lien amount to at least 40 per cent of the principal. In one district, they were one and one-third times the principal. Since construction assessments should be classified as capital investment, only the interest on these assessments, averaging about $1.47 per acre annually, can be charged as expense. Annual benefit charges averaged $2.14 per assessed acre. Other expenses such as state and county taxes, maintenance and depreciation of buildings, and miscellaneous improvements, and owner supervision are calculated to total $3.00 per acre annually. Thus the total yearly expense over the 29-year period averages about $6.88 per assessed acre, leaving a net return of $6.84 per assessed acre to the landowner. At 6 per cent this would indicate a value of $114 an acre. Considering the net income for the years of the Rice Lake record (1937–42) and allowing $1.00 for annual interest during those years, the average yearly net profit was $5.70 an acre; at 6 per cent this land would be worth $95.00 an acre.

Land in the West Matanzas District has recently sold for about $100 an acre and some in the Langellier District (enclosed by same levee system and having same pumping station as West Matanzas) sold with improvements for $104.55 an acre in 1941 (Table 6), which would indicate that our calculations on the value of leveed land, based on net income, are higher than the valuations on some of this land by recent buyers.

Our figures show that the net income from 1916 through 1944 indicates a value of about $114 an assessed acre, but (Table 3) in the West Matanzas District at least $183.97 per assessed acre has been spent for construction

TABLE 6.—SALE PRICES OF EIGHT LAND TRACTS IN LEVEE AND DRAINAGE DISTRICTS, FULTON COUNTY, ILLINOIS.

District	Year sold	Acres	Value of improvements per acre[a]	Sale price per acre	Subject to
East Liverpool	1943	560	$10.00	$ 69.64	Unpaid drainage assessments due after September 1, 1943.
Liverpool	1944	60	none	55.00	Levee and ditch rights-of-way and unpaid assessments.
Liverpool	1943	40	none	50.00	Annual benefit assessments.
Langellier	1941	2,018	12.00	104.55	Special taxes for incomplete improvements and general taxes, 1942 and subsequent.
Liverpool	1939	78	none	58.26	All special drainage taxes.
East Liverpool	1937	90	none	28.04	Taxes, 1937 and thereafter; annual benefit assessments. Sold by public auction.
East Liverpool	1937	20	none	23.40	Taxes, 1937 and thereafter; annual benefit assessments. Public auction.
East Liverpool	1937	149	none	29.63	Taxes, 1937 and thereafter; annual benefit assessments. Public auction.

[a] Estimated by the writer.

and repair work. The average of such expenditures for the four districts discussed is $218.23 an assessed acre.

The Illinois Tax Commission (1941) sums up the economic problems of Illinois drainage districts thus: "It would appear that many of these districts cannot hope to support the present system of levee and drainage facilities from the present collections of drainage assessments. The cost of the land is in excess of their earning power in agriculture production. In addition, periodic damages from several floods add unanticipated burdens to the cost of reclamation. No assurance can be given that maximum floods will not be exceeded. Since absolute protection against floods cannot be assured in the cultivation of bottomlands, some risk must be assumed on lands taken from the flood plain of the river."

The Rice Lake area yielded the U. G. Orendorff Company a gross return of $3,386.57 or $3.28 per acre. Expenses comprised the caretaker's salary, state and county taxes, and an allowance for the maintenance and depreciation of buildings and boats. The caretaker's annual salary (in addition to his income from boat rentals and a 50 per cent share of muskrats he trapped), was $900 in 1932–41 and $1,020 in 1942. State and county taxes averaged $600 a year. Maintenance and depreciation were calculated at $200 annually. Charges against the project totaled about $1,710.00 or $1.42 per acre. The net income probably could have been doubled and perhaps tripled if water levels had been partially controlled by a low dam and full value received from harvest of furbearers and hunting of ducks.

Even without the most efficient management, the Rice Lake project produced an income, capitalized at 6 per cent, of $23.40 an acre. Unleveed bottomland fields adjacent to Rice Lake produced incomes (at 6 per cent) of $63.17 and $39.50 per acre. J. Nelson Spaeth of the Department of Forestry, University of Illinois, estimates that under good management this area can produce pulpwood with an average net income of $3.00 to $4.00 per acre per year. This, at 6 per cent, is $50 to $67 per acre. Thus, bottomland tracts have a minimum value of about $25 an acre before levees and drainage works are built. Buyers of such tracts, interested primarily in duck hunting, have paid more than this in recent years (Table 7). The differences in value between leveed and unleveed land evidently are not sufficient to justify large expenditures for construction of levee and drainage works.

It has been suggested that such

TABLE 7.—SALE PRICES OF UNLEVEED BOTTOMLANDS, USED PRIMARILY FOR DUCK HUNTING.

Place or Club	*Sold*	*Acres*	*Improvements per acre*[a]	*Price per acre*
Clyde Bell	1944	70	none	$ 40.96
Connor	1944	109	none	55.05
David Joyce	1943	410	$36.60	104.80
Rice Lake	1943	2,200	6.60	37.50
Wing Feather	1943	225	none	38.46
Fletcher Lake	1940	80	none	60.00

[a] Estimated by the writer.

tracts would decrease in value if more land were available for duck hunting purposes. Actually the number of potential waterfowl hunters in the state is so large that the demands of hunters would still remain unsatisfied if all suitable land were converted to waterfowl hunting areas; and no significant decrease in value of duck lands would result. Were sufficient land available, there probably would be five times as many duck hunters in Illinois as at present. The Dakotas, Minnesota, Wisconsin, and Michigan (with many times the acreage of waterfowl habitat in Illinois) have about five times as many duck hunters as Illinois, in proportion to their population. At present, about three of five waterfowl hunters in Illinois have difficulty in finding places to shoot ducks.

TABLE 8.—FLOOD CHANGES IN THE ILLINOIS RIVER VALLEY, 1904–26.[a]

Region	Area of flood plain		Average increase of flood stage, feet	Storage in acre-feet		
	1904	1926		1904	1926	Change
La Salle to Peoria	59,430	57,120	0.78	828,400	832,000	+ 3,600[b]
Peoria to Havana	55,700	20,500	2.75	587,000	280,000	−307,000
Havana to Beardstown	60,600	54,580	4.98	582,800	635,000	+ 52,000[b]
Beardstown to Valley City	67,000	11,670	5.59	589,800	194,400	−394,000
Valley City to Pearl	40,400	5,860	3.68	296,000	74,600	−221,000

[a] Mulvihill & Cornish (1929).
[b] Increase, despite reduction in area, by heightened water level.

DRAINAGE DISTRICTS AND FLOOD CONTROL

Destructive floods occurred in the Illinois River Valley in 1844, 1904, 1913, 1922, 1926, 1927, 1943 and 1944. According to Mulvihill and Cornish (1929): "Floods have reached successively higher stages, not because run-off or discharge of the river has increased since the first recorded flood of 1844, but because landowners since 1900, under provision of the state laws, have been allowed to build levees and encroach upon the natural flood plain of the river. Drainage and levee districts were organized under the laws of the state to reclaim bottomlands. Each district that has built a levee has shut off a portion of the natural flood flow channel, thus adding to the flood heights and increasing the flood hazard of all other districts. . . . Before levees were built a very large portion of the flow of major floods passed downstream over the wide valley. Between Beardstown and Hardin the valley was from two to four miles wide and more than 95 per cent of this area has been leveed. Approximately 50 per cent of the discharge of a major flood crest passed over the valley. Similar conditions prevail between Pekin and Havana, where about 75 per cent of the land has been leveed. With levees holding, the water must rise high enough in the channel and over the narrow floodway between the river channel and the levee or foothills to compensate for this reduced floodway area."

Data obtained by these authors show

that changes in the flood plain of the Illinois River by construction of levees between 1904 and 1926 resulted in increased flood stages (Table 8). The average increase varied from 0.78 feet from La Salle to Peoria where only 2,310 acres were removed from the floodway by levees, to 5.59 feet from Beardstown to Valley City where 55,330 acres were removed. If the former 3,300-acre Chautauqua Drainage District were restored, flood stages would now be 1.5 feet higher at the head of the district near Liverpool, and 0.75 feet higher at Peoria, and river levels would be raised to La Salle, about 60 miles above Peoria.

These and other data presented by Mulvihill and Cornish make it evident that leveed districts in the flood plain of the Illinois River have materially raised flood heights, and doubtless increased damage to urban and industrial areas as well as to unleveed farm lands.

Calculated from data in the "Report on the Lower Illinois River Basin" (Anonymous, 1940), flood damages to industrial and urban properties were $2,500,000 in 1922, $2,500,000 in 1926, and $1,400,000 in 1927.

The flood control work by the Corps of Engineers has consisted of bigger and better levees around drainage district farm land. The federal government, in the late 1930's, repaired and enlarged the levees at a cost of $598,600.00, about $56.20 for each acre in three of the four districts discussed earlier. Judging from land sales then, at prices somewhat lower than usual (Table 6), the entire districts might have been purchased for the money spent on levee improvements. Levee improvements in those districts may prevent floods on the enclosed private land, but contribute nothing to solving the general flood problem in the Illinois River Valley. During the past few years the South Beardstown levee has been moved back several hundred yards, creating a wider floodway for a short distance below Beardstown. By and large, however, public money spent to reduce floods has increased the flood hazard.

TABLE 9.—INCREASED FLOOD HEIGHT IN FEET OF ILLINOIS RIVER IF LEVEES HAD NOT BROKEN IN 1926, REDUCING FLOOD CREST THROUGH STORAGE.[a]

Place	
Peoria	1.33
Copperas Creek	1.92
Liverpool	1.93
Havana	1.73
Beardstown	1.79
Meredosia	2.56
Valley City	2.20
Pearl	2.89
Kampsville	1.97

[a] From Mulvihill & Cornish (1929).

In 1943 Beardstown was saved from a flood of 5 or more feet only by great effort and the lack of strong winds, which by wave action would have broken the levees. Many industrial plants in Peoria were threatened or suffered serious losses. The floods forced hundreds of people in towns and cities along the river to leave their homes, which were severely damaged. It is not implied that urban or industrial areas would have escaped damage if there had been no drainage districts, but the districts created a higher flood crest; indeed this would have been even higher, had not about half of the levees broken and released the flood water. Table 9 discloses the effect of levee breaks during 1926 in reducing the flood height along the Illinois River.

RECOMMENDATIONS

Federal and state wildlife agencies should accelerate research on the management of wet lands and place the results in readable form for land owners. The latter then would be less likely to drain or condone drainage; and many owners of drained wet lands, relatively unprofitable under cultivation, would be interested in restoring the marshes or lakes.

Agencies concerned with flood control and land use should seriously consider restoring unprofitable drained areas which make for increased flood heights. Despite all the federal expenditure on levees and drainage districts in the Illinois and Mississippi river valleys, the flood and economic problems continue, and little has been done toward a lasting solution of flood problems there. The purchase and establishment of certain districts as flood reservoirs and flowage ways would be a start toward this end. Such areas would aid in lowering flood heights and also furnish a comparatively high economic return from the harvest of aquatic resources; in addition, they would be of great value to local residents by providing much needed recreation grounds.

SUMMARY

1. There is a dearth of information on the value of wildlife resources to owners of marsh lands. There has been much misguided land use and many unwise "flood control" projects, partly because of the scant information on comparative values of drained and undrained land.

2. Many land owners in the United States and Canada have derived substantial income from muskrats and other furbearers, but few marsh lands are managed for maximum returns.

3. A study was made of Rice Lake, a 1,034 acre bottomland lake in the Illinois River Valley between Peoria and Havana, which is a good muskrat area, of average value for duck hunting and fishing, but little utilized for commercial fishing.

4. From 1937 through the trapping season of 1942–43, the U. G. Orendorff Company, owners of Rice Lake, received an average annual income of $878.74 from the sale of fur pelts, $2,114.17 from duck hunting lease rights, and $393.66 from boat rentals to hook-and-line fishermen.

5. Several local residents also received income from trapping furbearers and acting as guides for duck hunters.

6. Raising the water level of the lake 2 to 3 feet by an inexpensive dam would have increased the annual gross income from duck hunting by $400 to $800, the annual catch of muskrats by 200 to 800 pelts, and that from boat rentals by $200 to $700.

7. Levee and drainage districts have reduced the flood plain of the Illinois River valley by about 192,000 acres, almost half.

8. The average construction assessments in four nearby levee districts were $161.42 per assessed acre. Up to 1945, flooding of three districts had damaged farm improvements by $7.65 per acre. Federal expenditures since 1939 to raise and improve the levees averaged $49.15 additional per assessed acre.

9. Illinois River levee and drainage districts have received other aid through the CCC, WPA, RFC, and in outright grants by the state.

10. Besides construction costs, most such districts have annual operating expenses, covered by an annual benefit tax, usually of $2.50 an assessed acre.

11. Comparison of the calculated income with the construction and operating expenses in the West Matanzas Levee and Drainage District shows that the landowners received a net return of about $6.84 per assessed acre from 1916 to 1944, indicating a value, at 6 per cent, of $114 an acre. For the same years as data are available for Rice Lake, 1937–42, the net annual income was $5.70, indicating a value of $95.00 per acre.

12. At the time of this study two unleveed bottomland fields in the Rice Lake area had, by comparison, values of $63.17 and $39.50 per acre, respectively. The net income from wildlife resources of unmanaged Rice Lake, capitalized at 6 per cent, was $23.40 an acre. With adequate management of water levels and of the harvest, this probably could have been doubled or tripled. Under proper management for pulp wood, the timber about Rice Lake would be worth $50 to $87 per acre.

13. Levee and drainage districts in the Illinois River Valley have encroached upon much of the floodway of that stream, and have increased flood heights from 0.78 to 5.59 feet in various parts.

14. Despite large state and federal expenditures, the local flood control problem has not been solved because larger levees have been built, primarily around agricultural land, rather than increasing the storage and flowageway of the river. Flood damage to urban and industrial properties and unleveed farm lands amounted to $2,900,000 in 1922, $3,100,000 in 1926, and $1,650,000 in 1927.

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ECOLOGICAL CLASSIFICATION OF COVER TYPES

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The cover map is an essential tool without which no manager of wild lands would attempt to operate. Nevertheless cover maps and cover mapping technics vary so greatly that the map used by one group may be almost unintelligible to another. A certain amount of variability is inevitable because the details required for one activity differ from those of another, and maps must be made to meet specific purposes, yet the principles involved are always the same. It would seem, therefore, that less diversity might reasonably be expected, and certainly more uniformity would be desirable. Some variations arise because no generally acceptable set of symbols has been proposed and others result from different basic assumptions made by those engaged in cover mapping.

Two viewpoints are common. The first and older idea grew from the matter-of-fact assumption that the objective of cover mapping had been satisfied when the existing cover was classified and mapped to show the predominant plants actually on the ground. Such maps give no indication of the origin of the types. Furthermore, the method assumes either that future changes will occur so slowly that they will not soon outdate the map or that changes cannot be predicted and therefore should not be considered in mapping.

On such maps the cover type is indicated by the name or names of predominating species like elm, aspen, or perhaps by some general name like mixed hardwoods or grasslands. Any of these types may develop on either low or high land, and, although the predominant species may be the same, the character of the type and especially the associated plants and animals exhibit marked differences that are not evident on a map showing only the existing predominant cover. The same type species of plants, especially trees, may often be found on both heavy and light soils, and contrasting conditions often exist between the biota of the two sites although the types are designated on the map by the same name.

The usual forest type map,[1] most

[1] Society of American Foresters Committee. 1932. Forest cover types in eastern United States. Journ. Forestry, 30: 451–490.

land and economic suvey maps, and numerous others fall into this first category. In combination with soil and contour maps they can be interpreted for general purposes, but from the viewpoint of long-time management they are not so useful as they should be when the cost of making them is considered.

The second and more recent viewpoint, in contrast to the purely descriptive procedure, recognizes that conditions are continually changing, that some types are transient and others are more stable, and that the sequence of ecological change proceeds in an orderly manner. Maps made on the basis of these assumptions not only show existing conditions but also indicate from whence each type has arisen and whither it is headed. Because of their dynamic character they are far more useful in wildlife management and in silviculture than those that record only existing conditions.

Wight[2] formulated a type classification for southern Michigan based upon ecological succession that has been used for more than ten years. During that time most of Washtenaw County has been mapped using his classification. Dalke[3] developed similar classifications for use in Connecticut and Missouri, and still other persons have formulated ecological classifications of cover types in other localities. The various cover classifications are based upon the same ecological principles, but it sometimes is difficult, without considerable study, to compare the maps of one region with those of another and recognize the ecological stages represented by each type.

This difficulty was brought forcibly to attention when an attempt was made to modify Wight's classification for southern Michigan to use in conditions at the summer camp of the University of Michigan School of Forestry and Conservation in the Upper Peninsula. In several courses students are required to map cover in both of these widely different localities. It seemed that they might become confused unless they could be shown the similarities as well as the differences between the two places. Use of the same symbols for comparable ecological stages in the north and south made these similarities clear. Although the particular plants and animals might often be different, the students recognized that those representing comparable stages of development were essentially ecological equivalents.

The types were arranged in an orderly sequence of stages for each of the various ecological series characteristic of the two localities. Each symbol or combination of symbols represented a stage of development and therefore was equally applicable to conditions in either the Upper Peninsula or southern Michigan, although the predominant species often were taxonomically different.

Students learned the system quickly and when their work was shifted to southern Michigan, they were able to adjust easily to the new conditions without confusion. In the new locality it was not necessary to learn a new

[2] Wight, H. M. 1934. The cover map and game census in pheasant management. Amer. Game Conf. Trans., **20**: 329–333.

[3] Dalke, P. D. 1937. The cover map in wildlife management. Journ. Wildl. Mgt., **1**: 100–106. 1941. Development of a statewide system of cover mapping applicable to Missouri wildlife range, Journ. Wildl. Mgt., **5**: 103–107.

TABLE 1.—ECOLOGICAL CLASSIFICATION OF COVER TYPES (MICHIGAN SYSTEM).

	Upland types—Terrestrial origin			Lowland types—Aquatic origin				Transition types	
				Bogs		Marshes			
	Porous soils P	Nonporous soils A	Rock outcrops R	Seepage BS	Stagnant B	Seepage MS	Stagnant M	Flood plain F	Transition belts E
1	Bare soil	Bare soil	Bare rock	Saturated soil or water	Water	Saturated soil or water	Water	Bare soil	Same as corresponding water or dry land type
2			Crustose lichens		Submerged vegetation		Same as B2		do.
3			Foliose lichens and moss						do.
4	Moss and annuals	Same as P4	Same as P4	Sphagnum sedge mat	Same as BS4	Emergent aquatics	Same as MS4	Annuals	do.
5	Grass and other perennials	Same as P5	Same as P5	Sphagnum sedge and heaths	Same as BS5	Emergents and sedge-grass	Same as MS5	Same as P5	do.
6	Mixed herbaceous	Same as P6	Same as P6	Heaths predominate	Same as BS6	Same as P6	Same as P6	Same as P6	Same as P6 or BS6
7	Shrubs	Shrubs	Shrubs	Swamp shrubs	Same as BS7	Same as BS7	Same as BS7	Same as P7	Same as P7 or BS7
8	Intolerant trees	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8	Same as P8
9	Mid-tolerant trees	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9	Same as P9
10	Tolerant trees	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10	Same as P10

	Physiographic conditions—Exponential letters	Disturbance effects—Sub-letters	Timber size and stocking
"Same as" = Ecological equivalent not necessarily identical species.	o—Outwash d—Dunes k—Kettle hole l—Calcareous g—Igneous rock s—Shale m—Glacial drift b—Loess	d—Drained P—Pastured e—Eroded f—Flooded y—Cutover x—Burned a—Wild animal grasing and browsing b—Blowdown	' Scattered '' Medium ''' Dense Diameter in inches: 4–6, 4–12, 8–16, etc. **Shrub Density** — Scattered = Medium ≡ Dense

classification. After a few hours in the field they were able to recognize the ecological equivalents, and then could map with equal facility in either place. In fact, our experience suggests that the system is suitable for rather general application. If this should prove true, and if the same or a similar system were adopted, a greater uniformity in cover maps might be attained, whereby workers in one locality could more easily understand and interpret maps of workers in other localities.

The basic subdivisions of the Michigan classification are presented in Table 1. The types are divided into three principal groups depending on their origin and character: upland types, lowland types developed from water areas, and transition types either highland or lowland. Each of these is subdivided into two or more series indicated by capital letters (P, BS, etc.). A more exact description of each series may be indicated by adding exponential lower case letters. For instance R stands for series on rock outcrops; R^l=limestone outcrops; R^g=igneous rock; and R^s=shale outcrops. Other subdivisions using exponential letters not presented in this tabulation will be needed in different localities or for special purposes and can be added to the outline without modifying the basic arrangement. In other instances it may be unnecessary to use exponential symbols.

Often the normal sequence in a series may be disturbed by the works of man, the activities of animals, or natural catastrophies, and sub-series may follow. These conditions are indicated by sub-letters. Those most often needed under Michigan conditions are indicated in Table 1, but others will be required in different localities. Care must be taken to avoid adding unnecessary symbols, else the system becomes too complex to be practicable. Some disturbance series characteristic of Michigan will be discussed later.

The succession of ecological stages through which each series passes as it develops toward the climax type have arbitrarily been divided into stages (1 to 10) that can be recognized easily.

The transition types are likely to cause the greatest difficulty and have usually been neglected in cover mapping, yet they often are the most important elements from the standpoint of animal life. The largest of these are the flood plains, between water and high ground, that are rich and productive of a great variety of life. Only when they occupy a considerable area is it customary to show them on a type map. Often they are narrow strips along streams and seem too insignificant to map, even though the existence of some animal may depend upon such a strip. Under the Michigan system they can be shown even when so narrow as to be indicated only by a line. Inserting the proper symbol (at a break in the line) will indicate clearly the conditions existing. Transition zones between principal types may thus be shown. The character of swamp margins, fence rows, woodland edges, and other ecotonal strips can be made clear on the map.

Only a single series of symbols are needed to indicate conditions in transition belts, although they may have been variously derived, from either wet or dry conditions. Their origin is evident from the character of adjacent types. Thus an E6 strip between MS4 and A10 types would not be the same as an

TABLE 2.—SOME PLANTS CHARACTERISTIC OF THE VARIOUS TYPES IN NORTHERN MICHIGAN.

	Upland types—Terrestrial origin			Lowland types—Aquatic origin				Transition types	
				Bogs		Marshes			
	Porous soils P	Nonporous soils A	Rock outcrops R	Seepage BS	Stagnant B	Seepage MS	Stagnant M	Flood plain F	Transition belts E
1	Bare soil	Bare soil	Bare rock	Saturated soil or water	Water	Saturated soil or water	Water	Bare moist soil	Same as corresponding wet or dry type
2			Crustose lichens		Pond weeds Water lilies		Pond weeds Water lilies		do.
3			Foliose lichens Mosses						do.
4	Mosses and annuals	Little moss Annuals Perennials starting	Mosses Lichens Scattered annuals	Sphagnum-sedge mat Pitcher plant Cotton grass	Sphagnum-sedge mat Pitcher plant Cranberry	Bullrushes Cattails	Bullrushes Cattails	Annuals Perennials starting	do.
5	Sedges Bunch grass Scattered perennials	Timothy clover Sod grasses Goldenrod Asters	Scattered perennials Mosses persisting	Sphagnum sedges Labrador tea Bog rosemary	Sphagnum sedges Labrador tea Cranberry	Sedges Grasses Cattails	Sedges Grasses Cattails	Grasses Scattered perennials	do.
6	Bluegrass Sedges Mixed perennials	Sod grasses Bracken fern Mixed perennials	Grasses Mixed perennials	Heath bog of Laborador tea Sphagnum Leatherleaf	Heath bog of Laborador tea Leatherleaf	As above + various large perennials	As above + various large perennials	Mixed perennials crowding out grass	do.
7	Ceanothus Sweetfern Cherry Blueberry	Raspberry Blackberry Hazel Dogwoods	Blueberry Ceanothus	Bog birch Highbush cranberry Dogwoods	Usually this stage absent	Highbush cranberry Dogwoods Alder Holly	Dogwoods Alders near margins	Berry bushes Mich. holly Alders Dogwoods	do.
8	Paper birch Jack pine Some aspen	Aspen Yellow birch White and red pine starting	Jack pine Cherry Black spruce	Tamarack Black spruce White cedar	Tamarack Black spruce	Mountain ash Aspen Willow Ash White cedar Balsam fir	Aspen Tamarack Willow Black spruce	White ash Aspen Paper birch Elm	do.
9	Red pine White pine Oaks	Elm Yellow birch White pine White spruce Balsam fir	Red pine Black oaks White pine	Red maple Yellow birch Elm Ash White pine	Red maple Yellow birch Elm Ash White pine	Red maple Yellow birch White pine Balsam fir	Red maple Yellow birch Black ash Black spruce	Red maple Yellow birch White ash White pine	do.
10	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood	Sugar maple Hemlock	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood	Sugar maple Hemlock Basswood

TABLE 3.—SOME PLANTS CHARACTERISTIC OF THE VARIOUS TYPES IN SOUTHERN MICHIGAN.

	Upland types—Terrestrial origin			Lowland types—Aquatic origin				Transition types	
				Bogs		Marshes			
	Porous soils P	Nonporous soils A	Rock outcrops R	Seepage BS	Stangant B	Seepage MS	Stagnant M	Flood plain F	Transition belts E
1	Bare soil	Bare soil	Bare rock	Saturated soil or water	Water	Saturated soil or water	Water	Bare moist soil	Same as corresponding wet or dry land type
2			Crustose lichens		Pond weeds Water lilies		Pond weeds Water lilies		do.
3			Foliose lichens Mosses						do.
4	Annuals Mosses seldom	Annuals grasses and perennials starting	Mosses Lichens Scattered annuals	Sedges Sphagnum seldom	Sedge mat Sphagnum usually Bog plants	Bullrushes Cattails	Bullrushes Cattails	Annuals Perennials starting	do.
5	Various grasses Scattered perennials	Sod grasses Goldenrod Asters	Scattered perennials Mosses persisting	Sedges Leatherleaf Scattered perennials	Sphagnum Leatherleaf Sedges Cranberry	Sedges Grasses Cattails	Sedges Grasses Cattails	Sod grasses Scattered perennials	do.
6	Bluegrass Mixed perennials	Bluegrass Mixed perennials	Grasses Mixed perennials	Mixed perennials	Leatherleaf over sedges and sphagnum	Various mixed perennials	Various mixed perennials	Various mixed perennials	do.
7	Panicled dogwood Rose Rubus	Dogwoods Rose Rubus Witchhasel	Dogwoods Hazel Rubus	Highbush cranberry Dogwoods Willows	Dogwoods Huckleberry Chokeberry Spirea	Elderberry Dogwoods Willows	Dogwoods Buttonbush Willow near margin	Great variety of shrubs	do.
8	Aspen Sassafras Juniper	Aspen Juniper Crataegus Cherry	Crataegus Cherry Aspen	Tamarack Aspen Willows	Tamarack Black spruce	Aspen Willows Black ash Elm	Aspen Dogwoods Black ash Elm	White ash Aspen or other poplar Elm	do.
9	Elm Black oaks Hickories	Black and White oaks Hickories	Black oaks Hickories	Soft maples Swamp white elms Oak	Soft maples Yellow birch Hickories	Soft maples Elms Hickories	Soft maples Elms Black ash	Soft maples Hickories Oaks Elms	do.
10	Sugar maple Basswood Beech	Sugar maple Basswood Beech	Sugar maple Basswood	Sugar maple Basswood Beech	Sugar maple Basswood Beech	Sugar maple Basswood Beech	Sugar maple Basswood Beech	Sugar maple Basswood Beech	Sugar maple Basswood Beech

E6 between P4 and P10 types. Nevertheless, the character in each instance will be clear when the adjacent types are considered.

In the lowland types it is essential to distinguish between bog and marsh series, especially in the early stages of succession. The bog series are wet areas originally of open water but filled by thickening of a floating mat. The marsh series are wet areas originating from open water but filled from the bottom by accumulated plant material and wind- or water-borne debris. Each of these is in turn divided into stagnant wet lands and seepage areas through which water is flowing. These distinctions have frequently been overlooked in cover mapping wet lands, but they are important in determining vegetational differences. For instance tamarack may grow on either a stagnant bog or a seepage bog, but white cedar is seldom or never found in a swamp developed from a stagnant bog or marsh. The significance of such differences to animal life need only be mentioned to be appreciated.

Examination of Table 1 shows that all developmental stages do not necessarily appear in every series; but the same number always applies to comparable stages. For instance, 7 always indicates a shrub stage, 9 a mid-tolerant forest growth, and 10 a forest predominantly of tolerant tree species.

The complete series of 10 stages will occur only in forested regions. If this system were to be used in a prairie region, 10 would never occur, and 7, 8, and 9 would appear only along water courses or other moist spots. In such a region it would doubtless be necessary to divide stage 5 into several types by using appropriate exponential symbols to indicate the specific composition. For instance, $A^{b}5^{x}$ would represent a loess soil in the grass stage of type x.

Likewise in desert or forest regions it will frequently be necessary to divide some stages into specific types. In northern Michigan P8 might mean a stand of jack pine, paper birch, aspen, pin cherry, or perhaps a combination of these intolerant trees growing on porous soil. By adding exponential symbols to the stage number, the composition can easily be made clear. The Forest Service symbol for jack pine is 5; $P^{o}8^{5}$ would represent the jack pine type on outwash sand and $P^{m}8^{k}$ an oak type on sandy glacial drift.

The size of trees and degree of stocking also can be shown (Table 1). Thus, $P^{m}8^{5'''4-12}$ would represent a dense stand of jack pine 4 to 12 inches in diameter. Or if oak and jack pine were mixed on sandy glacial drift, forming a scattered stand 4 to 12 inches in diameter, the symbol would be $P^{m}8^{5-k'4-12}$.

In many cases, especially of a cover map used for wildlife management, the groundcover is just as important as the tree growth. Perhaps a jack pine forest may have a groundcover of blueberry or bracken fern. Groundcover can be shown by writing the appropriate symbols below the symbol for tree cover, like the denominator of a fraction. If b = blueberry and f = bracken fern, $P^{o}8\frac{5''4-12}{b\equiv}$ would mean a dense stand of blueberry growing under a medium dense stand of jack pine 4 to 12 inches in diameter on porous outwash soil; $P^{o}8\frac{5''4-12}{f\equiv}$ would mean that a ground-

cover of dense bracken fern instead of blueberry.

The importance of disturbance effects such as fire, erosion, floods, cropping of lands, grazing, wind storms, etc., can scarcely be overemphasized. They produce a diversity of conditions that otherwise could not exist and in that respect they are often beneficial in the long run. Conversely they may cause the destruction of immediate values that entails serious economic loss. From the viewpoint of cover mapping, however, they introduce complications in the form of subseries. In the main, the subseries following a disturbance is almost identical with a part of the primary series. In such cases the use of any special symbol to represent disturbance is not necessary, but often disturbances initiate series that for one or more stages are like no other series. In such cases a sub-letter after the series letter will indicate the condition existing.

For instance, following fire in northern hardwoods, especially a spring fire after cutting operations, almost pure stands of aspen are likely to develop. This condition would be represented by the symbol $A_{yx}8^{A}$. In the absence of fire such pure stands seldom occur, but aspen comes up in groups with other intolerant species. Fire on the same type without logging either causes no great change or, if severe, may initiate a pure stand of yellow birch ($A_xB_{\geq}^{YB}$), whereas cutting without fire usually is followed by a mixture of tolerant and intolerant trees. On lighter soils fire is usually followed by pure stands of paper birch ($P_x^m8^{PB}$) in northern Michigan, and on still poorer soils by jack pine ($P_x^08^s$) if seed is present. North of the Great Lakes fire on good soil may be followed by a pure stand of striped maple that persists generation after generation.

Fires in swamps are common during dry periods and in both northern and southern Michigan usually are followed by pure stands of aspen (B_x8^{A}) or by aspen mixed with yellow birch (B_x8^{A-YB}), or sometimes in the north by pure stands of alder that may persist for many generations.

Heavy cutting in swamps often increases shrubby growth, whereas lighter cutting may maintain the mixed coniferous stage longer than otherwise would be possible. Cutting in southern Michigan in B8 or B9 types usually is followed by a shrub stage (B_y7) in which poison sumach predominates. Thus in the normal sequence B_x7 in southern Michigan would seldom occur because aspen or yellow birch almost always seed into swamp burns, but B_y7 is common. Likewise in the north, heavy cutting in swamps is often followed by an increase of brush, such as alder, whereas fire is more often followed by trees.

From the discussion of ways in which the Michigan cover classification can be applied, it is evident that the system lends itself to any degree of detail required. By using exponential and subletters with the appropriate capital letter, both the physiographic and disturbance conditions may be represented. By adding exponential symbols, to represent predominant species, size, and degree of stocking, the specific composition of a type may be indicated. There is thus no limit to the degree of detail that can be represented.

Usually such extreme detail is neither necessary nor desirable and, although it

should be provided for in any system adaptable to all conditions, less detail will be adequate for the usual cover map. For instance, the exponential letters following the series letter may often be omitted if the physiographic features in the locality are uniform. Under such conditions the exponential letter would only be needed to indicate unusual conditions. Likewise the sub-letters need be used only in instances where disturbance effects have produced conditions differing from stages in the primary series. Thus $P8^5$ would be sufficient to indicate a jack pine type on porous soil, or $B8^5$ the same type in the bog series, an unusual type occasional on acid bogs. This flexibility in the amount of detail that can be shown makes it possible to fit this system of cover mapping to almost any situation.

It is necessary to adopt symbols to represent the various tree, shrub, and herbaceous species used to characterize types. Since these will vary locally, no list of species symbols is presented here. In each region the U. S. Forest Service has adopted a set of symbols to represent tree species. These may well be used as symbols for local species, adding new ones for shrubs and herbs as necessary. For uniformity it is desirable for all workers in a locality to use the same species symbols on their maps in so far as possible.

The differences and similarities between the various stages in northern and southern Michigan are shown in Tables 2 and 3, but only general and group names are used for the most part, because space does not permit listing many individual species. Otherwise greater specific differences between the two localities would be evident.

Many species are common to the two areas. In other instances northern species are replaced in southern Michigan by more southern species. The most conspicuous difference is not evident from this presentation of type classification, but would be evident on cover maps based on this system. Bogs will be numerous on a map of northern Michigan but less frequent in southern Michigan. Oak-hickory woodlands (A9) will appear frequently on a southern Michigan map, whereas in the North hickory will be absent and oak stands relatively less frequent. In the North, elm, ash, white spruce, white pine, yellow birch, and red maple are characteristic trees of A9 type. Other points of interest that need not be mentioned specifically will be seen by comparing the tables.

This discussion of the Michigan system of classification for cover mapping is presented in the hope that others may also find the scheme useful. Should it stand test under various conditions, it may lead to greater uniformity of cover mapping. More likely it may serve as a starting point from which, through discussion, a universally acceptable system may be developed by persons interested in cover mapping.

A VERSATILE BOAT FOR WATERFOWL MANAGEMENT AND RESEARCH

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Everyone who takes to the field after waterfowl, whether to hunt, study, or manage them, soon finds that many aquatic habitats frequented by the birds are practically inaccessible to him. Small tracts of waterfowl environment can be covered afoot or by poling light boats, but the usefulness of such means of transportation is limited when extensive acreages of shallowly flooded mud-flats, meadows, or marshes are encountered. When all these types occur together, and deep water as well, the difficulties of transporting men and equipment are increased many-fold.

In 1943 the writers were assigned to study duck sickness on the Bear River Marshes in Utah, an area encompassing vast acreages of each of the above types of environment. It was essential that some better means be found to cover the area. Naturally, attempts to solve transportation problems had previously been made by sportsmen and by those working on the area, but none of the resulting craft had proved entirely satisfactory. They varied from tractors with caterpillar treads to marsh boats with paddle wheels or screw drives that turned in the mud; those that suited one situation failed in others. Craft with water propellers were useful only in channels and open water where there was little danger of running aground or of fouling the propellers with aquatic vegetation. All of the craft were too cumbersome, and most of them were too slow to be practical.

The type of craft made essential by the varied environment and the nature of the work was one which: (1) could be operated in the field and also loaded off and on a trailer by one man; (2) would carry several men and their equipment equally well over marshes, meadows, and mud-flats covered with but a few inches of water, as well as over deeper areas filled with aquatic plants; and (3) would be capable of covering 30 or 40 miles of each or all of the above-mentioned environments in a day.

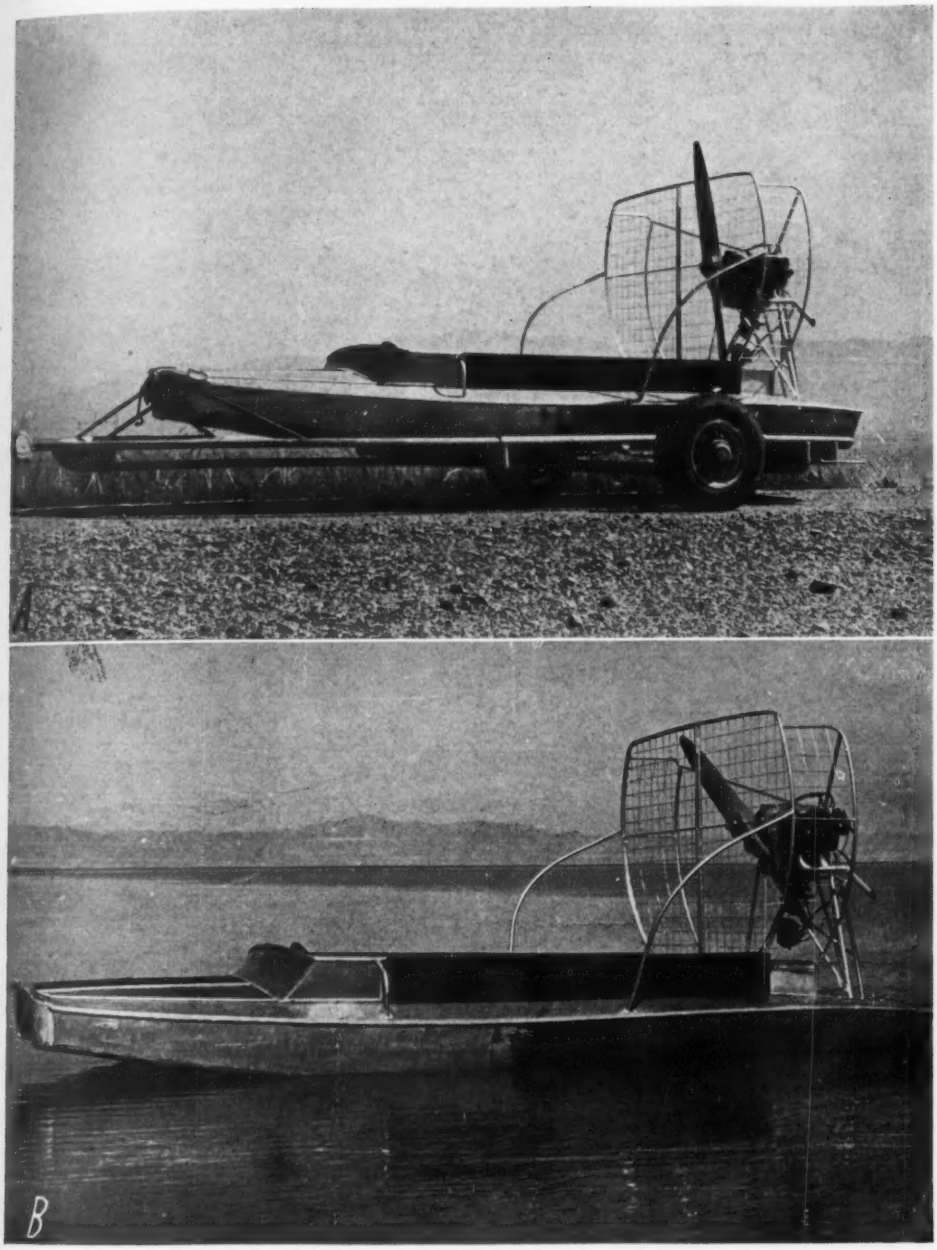
After preliminary experimentation, a boat was finally designed and constructed (Pls. 6, 7) which proved even more versatile than had been anticipated. Any desired speed, from trolling up to 35 miles per hour, may be attained over all types of environment from a wet mud-slick to deep water. At slow speeds in deep water, the draught is approximately 3 inches, whereas at higher speeds the boat planes. Over mud-slick the boat rides on the surface. The resulting friction is not noticeable, polishing rather than wearing the body. Obviously, however, such a craft should not be used in areas where the boat would have to ride on rocks or heavy gravel. It is maneuverable at all speeds and stable even in the rough water of shallow lakes despite the raising of the center of gravity by the elevated position of the motor. In gasoline consumption, the boat is more efficient than one using a large outboard motor. It has served for a day of field work at varying

speeds and covering 30 to 40 miles on about 8 gallons of fuel. It may be moved easily across dikes of moderate slope on greased boards.

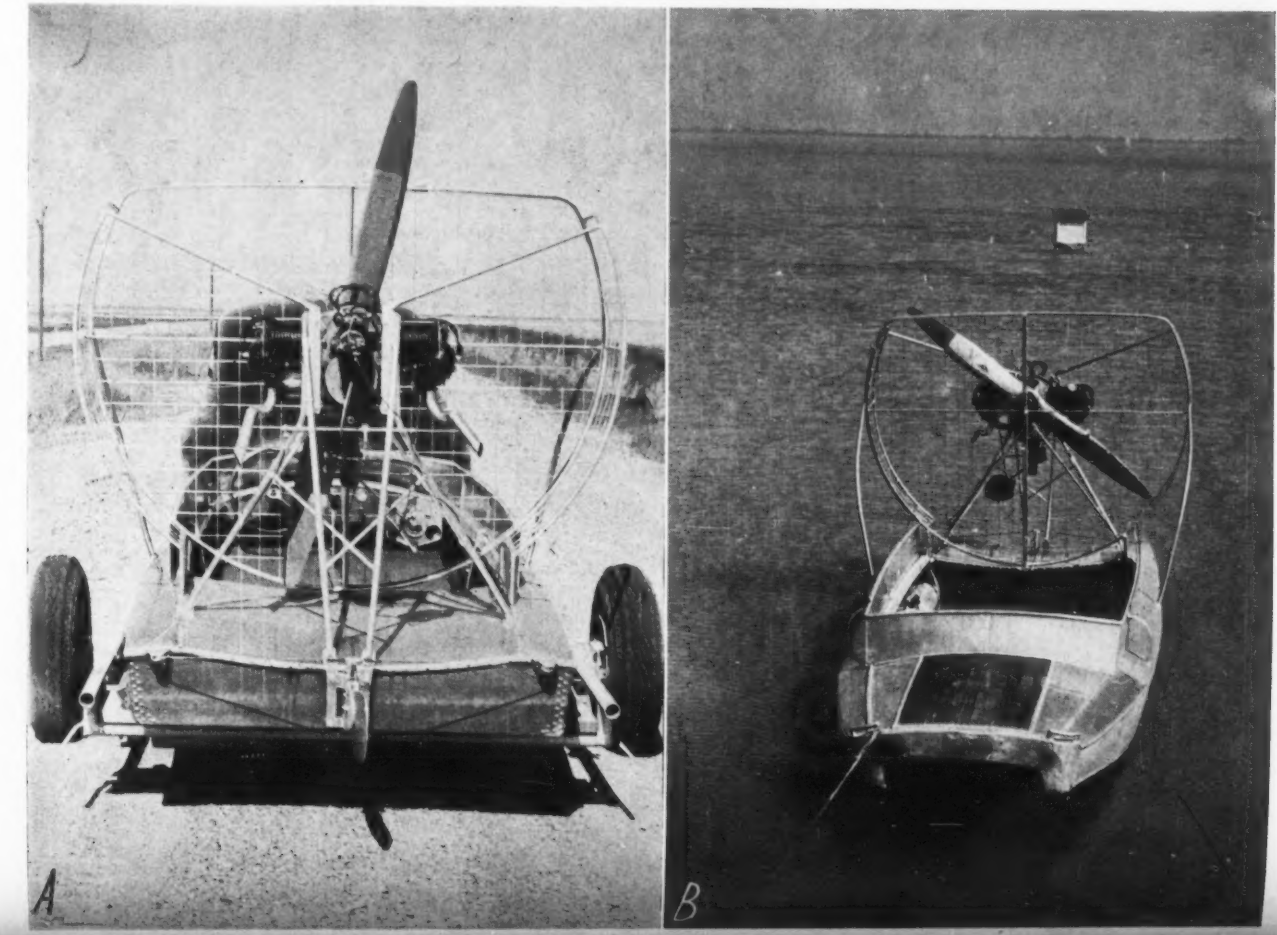
The appearance and general characteristics of the boat are apparent in the accompanying illustrations (Pls. 6, 7). The boat pictured was constructed for the Fish and Wildlife Service by Emil Johnson of Salt Lake City, Utah.

In its construction, the lightness and strength of duraluminum have been used wherever practical. The craft has the following approximate measurements: length, 14 feet; width, 52 inches; front decking, 4 feet; stern decking, 3 feet; well between decking, 7 feet by 44 inches; sides, 12 inches. The bottom is flat except for a tunnel that is 24 inches wide, about 3 inches deep at the bow, and tapers to 0 midway the length of the boat. The bottom and sides are of 12-gauge tempered dural; the deckings are of 16-gauge. For strength, all dural pieces are riveted together, not welded. Bracing in the inside floor consists of 2-inch dural angles with hardwood spars between at 1-foot intervals, crosswise. A 40-H.P. Continental airplane motor is supported on the stern decking by steel tubing. A steering wheel mounted in the dash controls a heavy rudder of 10-gauge galvanized iron mounted on the stern in such a way that its position varies up or down with the depth of water the boat is crossing. The propeller guard is mounted between the well and the motor, protecting the operator from accident. Half of the guard swings out, permitting the operator to crank the motor or work on it from within the boat. Removable splash boards on the sides are for use on the rough water of lakes. The boat is transported across land by a special trailer built to permit rolling the craft into the water and driving it back on easily.

Although this boat was designed primarily for use in duck-sickness studies on mud-flat and marsh areas, its speed, sturdiness, and lightness make it adaptable to other phases of waterfowl management. Recent trials in Colorado on the shallow Platte River and on the varied ice conditions of the Jumbo Reservoir showed that with a few additions it would be effective in rallying ducks from their resting grounds in places where they do winter damage to agricultural crops. It is also possible that such a boat, with cutting blades attached, will aid in controlling pest aquatics such as the water caltrop in the Potomac River. Other phases of waterfowl management and research in which the craft will likely find use are: (1) studies of flyway environments; (2) harvesting of aquatics; (3) trapping of waterfowl by herding concentrations of molting birds; (4) patrol and posting of refuge areas, otherwise inaccessible; (5) sanitation work in collecting sick and dead waterfowl; (6) mosquito control; (7) river investigations; (8) law enforcement; (9) census work and productivity surveys on both plants and waterfowl.



Versatile boat for waterfowl work. *A*. As mounted on trailer for overland travel. *B*. In the water, "bow" at left.



Boat for waterfowl work. *A*. Stern view as mounted on trailer. *B*. Bow view in water.

Boat for waterfowl work. *A*, Stern view as mounted on trailer. *B*, Bow view in water.

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FIG. 2.—Showing Works at Stage of Progress as Pointed to in Letter. B. How View in Water.

"PAUL BUNYAN" RAKE FOR REMOVAL OF MARGINAL VEGETATION IN BOTULISM CONTROL

Benjamin M. Hazeltine and Vernon Ekdahl
Lower Souris and Medicine Lake National Wildlife Refuges

Not all elements contributing to the cause or effect of toxic botulism are known, but laboratory and field tests have revealed that decaying vegetation contributes directly to devastating outbreaks of the disease among migratory waterfowl.

Management of the Bowdoin National Wildlife Refuge, Phillips County, Montana, from 1935 to 1942 brought to light problems pertaining to the rescue and treatment of affected birds and the disposition of the carcasses of dead birds. It also showed the need of initiating preventive measures to minimize the severity of the outbreaks.

Observations during the severe outbreaks in 1938, 1939, and 1940 showed as sources of contamination some small isolated bays and shores where over a period of years the prevailing winds had accumulated drifts of aquatic vegetation, chiefly detritus from sago pondweed and algae. Attempts with frightening devices to restrict feeding by the birds in these areas showed little success. Efforts also were made to agitate the water or otherwise create circulation in and near these presumed points of infection, but the results were only partly successful.

During the summer of 1941 we tried to remove the massive drifts of decaying vegetation. Large grappling hooks were first devised, but only a trifling amount of vegetation was removed. An under water type of "buck-rake" was then improvised of heavy angle irons; this was laboriously launched by several men pulling and lifting it out beyond the shoreline drifts and then the rake was hauled in with a large tractor. At first this appeared to be partly successful, but our hopes (and the buck-rake) were dashed on the first large boulder encountered beneath the drifts. A half yard dragline was next tried, but without success.

Finally a floating "raft-dozer" was constructed. This consisted of a raft of four 10-inch logs 14 feet long, spaced evenly and bolted at each end with 8×8 inch cross timbers about 10 feet long. The raft was decked with 2-inch planking and on one end an adjustable gate was built to act as a dozer in removing the drifts from the lake shore. The principle of operation was to float the raft-dozer out beyond the drift of vegetation, lower the adjustable teeth (of 2-inch hollow steel drill shafting), then draw the raft-dozer shoreward by cables with a D-7 Caterpillar tractor and force the load ashore above the water line. The teeth of the dozer were regulated by hand levers to correspond with the water depth as the shore was approached. The load, of 10 to 15 tons of decaying vegetation, was "pushed" ashore (Pl. 8, A).

The greatest difficulty in operation was to relaunch the raft-dozer, especially where the shore water was very shallow. We then used a small "22"

Caterpillar tractor and a push pole by which the raft-dozer was pushed out to where it would float. Then the process was repeated. Many tons of vegetational drifts were removed by this equipment, but our methods were cumbersome and successful operation required 4 to 6 men; because of curtailed WPA activities operation was restricted and further developments were needed.

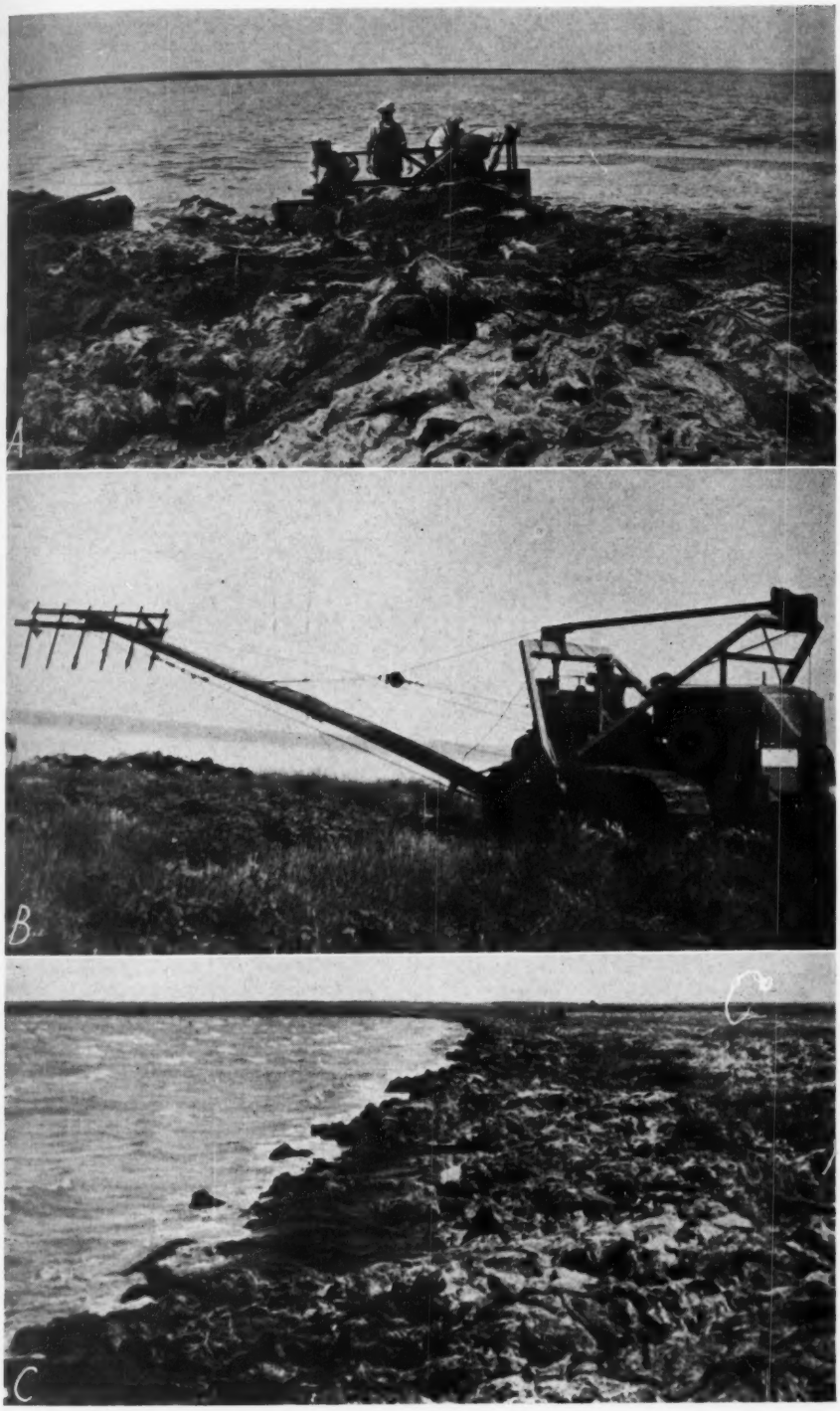
During 1942 conditions were almost identical as to drifts of decaying pondweed, but relief labor was lacking.

To manipulate the raft-dozer, a pusher was made by fastening a 40-foot cedar pole by a swivel hitch to the back drawbar of the D-7 tractor. This was raised or lowered by cables on the front power take-off drum, and kept centered by side cables from ends of a 12-foot crosspiece bolted to the rear of the tractor. The speed of the hoisting cable was reduced by an intermediate pulley (P. 8, B). The speed of the cable from the drum should be reduced two or three times by pulleys to permit better control and less strain on the equipment.

After completing the pole attachment, we conceived the idea of attaching a rake permanently to the pole, and built our "Paul Bunyan Rake." Angle irons of $4\times4\times\frac{1}{4}$ inches were used for cross pieces and braces, and the teeth were constructed of 2-inch drill shaft as on the raft-dozer. The rake is 10 feet wide, and the 6 teeth, each about $3\frac{1}{2}$ feet long, are spaced 2 feet apart. For extremely rotten vegetation an 18-inch spacing between teeth probably would be better, since the material tends to work back between them. A half-inch steel cable from the tractor drawbar was attached to the under side of the pole to take up the strain of the pull; otherwise the hitches at the ends of the pole would not stand the strain and probably would split the cedar pole and release the rake or the swivel hitches at either end. Other materials could be substituted for those in our rake, but the device pulls immense loads of water-soaked vegetation out of the lake and must be well constructed else it may fold up, particularly if a rock or other solid object be encountered.

The machine is manipulated by raising the rake well off the ground and then driving the tractor as near the water's edge as ground conditions will permit (Pl. 8, B). The rake is then lowered, and will sink by its weight through the vegetation to the bottom. The tractor then is driven away from the shore until the rake has drawn the debris well above the water line. In places where sago pondweed had accumulated in heavy drifts, we often moved a mass the width of the rake, 1 to 3 feet deep and up to 20 feet long at a single pull, which material would weigh several tons. After reaching the end of the pull, the rake was again raised and returned to the lake. Some cleared shoreline is shown in Plate 8, C.

A round trip with this contrivance required 2 to 5 minutes; while it did not carry so large a load as the dozer, the additional number of trips offset the advantage of the larger capacity. The chief advantage of the rake lies in the saving of man power, as one operator can operate both tractor and rake. If extremely boggy or rough ground is encountered, however, two operators should be used, one to manipulate the rake and the other the tractor.



A. From 10 to 20 tons of sago pondweed drift are brought ashore by the "raft dozer." *B*. Placing the "Paul Bunyan Rake" into position for another haul of sago drift. *C*. Sago drift removed from the water and piled along the shore. Attempts to burn the drift when dry were unsuccessful. Photos by U. S. Fish and Wildlife Service.

Under certain conditions soft ground may prevent the tractor from being used sufficiently close to the shore line to remove all of the debris, particularly if the drifts are very wide. But if a narrow strip next to the shore is removed, the wind and wave action will soon wash the remainder of the drift in toward the shore where it can be reached. By cleaning the first strip it was found that in a day or two a return trip could be made to take care of the remaining deposits.

Our apparatus was built to use with a D-7 Caterpillar tractor having an A-frame. Some modifications would be necessary for other types of tractors, but a crawler type tractor of 50 H.P. or more would be large enough to operate a rake of the size described. A somewhat lighter engine would have the advantage of greater maneuverability and ease of handling in soft ground; the D-7 had more reserve power than needed. If a D-7 or similar tractor is used, an addition could be made to raise the A-frame and permit greater leverage with the cable. At least 10 and possibly 20 feet then could be added to the length of the pole, a great advantage where the shore is soft and it is difficult to drive the machine close the water's edge.

With further use of this machine other improvements can be made that will be conducive to more efficient operations. The results may contribute materially to the control of botulism.

SOME SOCIAL FACTORS INFLUENCING QUAIL HUNTING IN MISSOURI, 1938-1944[1]

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One essential aspect of wildlife management deals with the wild species and their surroundings and another with regulation of the users of wildlife. In the latter, the manager and administrator are obliged to consider not only the ecological factors influencing the habits of animals, but also the social factors influencing the habits of sportsmen.

The present paper is non-biological in content. Certain social features of quail hunting in Missouri seem to have been clearly demonstrated, and also a study of the 7-year period ending in 1944 has made possible the comparison of several prewar and war situations.

The data were taken from complete hunting reports by an average of 403 (290 to 573) quail hunters each year. These sportsmen (including, about 6 women) hunted an average of 17,740 (13,754 to 25,821) hours per season, bagged an average of 26,531 (17,866 to 37,301) birds per season, shot down and lost, by their own admission, between 7 and 8 per cent of their bag, and hunted in an average of 110 (105

[1] Contribution from the Missouri Cooperative Wildlife Research Unit, U. S. Fish and Wildlife Service, American Wildlife Institute, Missouri Conservation Commission, and University of Missouri cooperating.

to 112) of Missouri's 114 counties. Statistical treatment of the figures indicates that the characteristics of these samples are reliable within a small margin of error when applied to Missouri quail hunters as a whole.

Quail are found in shootable numbers in every Missouri county and are distributed with fair uniformity. During the 7-year period, the open season throughout the state extended from November 10 through December 31 (52 days); the daily bag limit was 10 birds and the possession limit 15, with no seasonal bag limit.

METROPOLITAN VS. OTHER HUNTERS

The relative success of metropolitan and other hunters is of some interest to states having great urban districts such as those in and around St. Louis and Kansas City. The social conditions of life in a large city inevitably impose certain limitations upon both the activities and the success of metropolitan quail hunters in Missouri. This presents a very real problem to the wildlife administrator, responsible for development and public support of a long-term wildlife program. The writer suspects that some of the same limitations would be revealed by similar analyses of other types of hunting, or of quail hunting in other states. Should this be so, a recognition of the obstacles confronting the big-city sportsman is the first necessary step toward overcoming them, at least in part, although some clearly cannot be overcome.

In proportion to the metropolitan population of Missouri, few hunting reports have been received from those districts but these have been enough—as the consistency of the results will show—to make a fair comparison between the activities and successes of the urban hunters and their small-city, small-town, and rural brethren (Table 1).

Using the data from all seven years would be expected to eliminate differences ascribable to weather and other local or temporary influences. The following points of comparison seem clear, mentioning the metropolitan hunters first in each case:

1. As a group they averaged fewer trips and fewer hours afield per season than other hunters (24% and 16%, respectively).

2. Their trips were more sharply reduced in number during the war years than those of other hunters. They averaged 9.2 trips per season in the prewar years 1938–41 and 6.8 trips in the war years 1942–44, a reduction of 26 per cent. The other hunters averaged 11.0 trips per season in 1938–41 and 10.2 in 1942–44, a reduction of only 7 per cent.

3. Their hunting hours were more reduced during the war years than those of other hunters, but the difference is smaller than of hunting trips. Metropolitan hunters averaged 39.5 hours per season in 1938–41 and 34.0 hours per season in 1942–44, or 14 per cent less. The other hunters averaged 46.5 hours per season in 1938–41 and 41.4 hours in 1942–44, a reduction of 11 per cent. The average number of hours per trip has not varied greatly, usually being slightly over four hours for both city and rural hunters, both before and during the war.

4. The metropolitan hunters travelled farther afield than other hunters, and did a larger proportion of their hunting on the 12 "special days" (Table 1).

TABLE 1.—COMPARISON OF METROPOLITAN (M) AND OTHER (O) QUAIL HUNTERS IN MISSOURI, 1938–44.

		1938	*1939*	*1940*	*1941*	*1942*	*1943*	*1944*	*Averages*
Number of hunters	M	16	31	19	30	48	40	33	31.3
	O	557	491	325	260	299	328	346	372.5
Average trips per hunter	M	10.8	8.6	8.3	9.0	5.5	6.5	8.3	8.1
	O	9.9	11.9	10.8	11.5	10.4	10.4	9.9	10.7
Average hours per hunter	M	43.3	36.9	38.9	38.9	34.2	32.3	35.5	37.1
	O	44.5	48.5	44.6	48.4	42.6	42.8	38.9	44.3
Percentage of hours hunted In home and adjoining counties	M	*28.9*	*15.4*	*20.1*	*24.4*	*33.3*	*25.4*	*40.3*	*26.8*
	O	*62.9*	*64.3*	*87.9*	*86.8*	*95.7*	*87.7*	*92.5*	*82.5*
On 12 "special days" of season[a]	M	*40.3*	*45.5*	*52.7*	*54.0*	*50.6*	*64.2*	*67.1*	*53.9*
	O	*31.9*	*28.0*	*46.0*	*46.7*	*39.8*	*53.5*	*43.0*	*40.4*
Coveys flushed per 8 hours[b] All counties	M	—	—	—	—	—	5.41	4.54	4.98
	O	—	—	—	—	—	6.93	6.95	6.94
Counties hunted by metropolitan hunters	M	—	—	—	—	—	5.41	4.54	4.98
	O	—	—	—	—	—	6.26	6.40	6.33
Birds bagged per gun-hour All counties	M	1.12	1.03	0.95	0.83	0.82	1.11	0.94	0.97
	O	1.47	1.75	1.31	1.34	1.56	1.58	1.59	1.51
Counties hunted by metropolitan hunters	M	1.12	1.03	0.95	0.83	0.82	1.11	0.94	0.97
	O	1.50	1.87	1.33	1.31	1.53	1.45	1.51	1.50
Percentage success of metropolitan to other hunters									
All counties									
Coveys flushed per 8 hours		—	—	—	—	—	*78.1*	*65.3*	*71.7*
Birds bagged per gun-hour		*76.2*	*58.9*	*72.5*	*61.9*	*52.6*	*70.3*	*59.1*	*64.5*
Counties hunted by metropolitan hunters									
Coveys flushed per 8 hours		—	—	—	—	—	*86.4*	*70.9*	*78.7*
Birds bagged per gun-hour		*74.7*	*55.1*	*71.4*	*63.4*	*53.6*	*76.6*	*62.3*	*65.3*
Percentage of bag shot down but lost[c]	M	—	*6.9*	*7.6*	*8.6*	*10.6*	*9.8*	*8.9*	*8.7*
	O	—	*7.3*	*7.1*	*6.6*	*7.4*	*8.2*	*7.8*	*7.4*

[a] Heaviest hunting pressure on 12 "special days" of season: first two and last two days, Thanksgiving Day (but not Christmas), and Sundays.
[b] Not reported until 1943.
[c] Not reported in 1938.

5. Their hunting territory was further reduced in area during the war years than that of other hunters. In 1938–41 they averaged only 22.2 per cent of their hunting hours in home counties and adjoining counties, but in 1942–44 the figure was 33.0 per cent, an increase of 49 per cent. The other hunters in 1938–41 averaged 75.5 per cent of their hours in home or adjoining counties, whereas in 1942–44 the figure was 92 per cent, an increase of only 22 per cent.

6. Metropolitan hunters found their

hunting more restricted to the special days during the war years than did the other hunters. In 1938–41 the former averaged 48.1 per cent of their hunting on these days; in 1942–44 the figure became 60.6 per cent, an increase of 26 per cent. The other hunters in 1938–41 averaged 40.2 per cent of their hunting on the special days; in 1942–44 this figure was 45.4 per cent, an increase of only 13 per cent.

7. The metropolitan hunters flushed an average of fewer coveys per day than the other hunters, and bagged only half to three-quarters as many birds per gun-hour, shooting down and losing a larger proportion.

8. The contrast between metropolitan and other hunters as to hunting success is the same whether the comparison is made everywhere or only in the counties visited by the metropolitan sportsmen.

At least some reasons for these marked differences are readily discernible and will occur to any reader who has lived in a large city or has experienced the wartime shortages of gasoline, tires, ammunition, and time. They are in no sense discreditable to the metropolitan hunters but are fruits of a social system, made more conspicuous by wartime conditions.

There is generally poorer quail range within a county or two of the Missouri metropolitan districts than in most other parts of the state. Thus metropolitan hunters not only were obliged to restrict their hunting territory to an increasing degree, but this necessity also confined them more and more to poorer range.

Through the ordinary requirements of their affairs and because at all times they must travel farther for good hunting, metropolitan hunters are usually obliged to make their plans ahead and to go when planned, often regardless of unfavorable weather. This is doubtless the principal reason why they plan more of their hunting trips on the 12 special days. To understand, however, how this situation militates against hunting success, it must be understood that, other conditions being equal, the average number of birds bagged per gun-hour tends to be lower on these special days. This can be illustrated in two ways. First, Table 2 shows a consistent difference between average hunting success on the special days as compared with the other days of the season. Hunting on the "other" days thus is likely to average 10 per cent better, other conditions being equal. Any increased restriction of hunting to the special days therefore is likely to reduce average hunting success.

The other way to demonstrate the effect of this limitation upon the success

TABLE 2.—AVERAGE HUNTING SUCCESS ON SPECIAL DAYS AND OTHER DAYS.

	1938	*1939*	*1940*	*1941*	*1942*	*1943*	*1944*	*Averages*
Birds per gun-hour:								
All "special days"*	1.41	1.63	1.22	1.24	1.36	1.46	1.47	1.40
All other days	1.47	1.76	1.40	1.35	1.55	1.64	1.63	1.54
Percentage greater hunting success on other days	*4*	*8*	*15*	*9*	*14*	*12*	*11*	*10*

* See footnote "a," Table 1.

of metropolitan hunters is to compare the amounts of hunting on the several days of the week. Eliminating the first two and last two days of the season and Thanksgiving Day (inclusion of which would have rendered the results atypical) the hours of hunting and hunting success on each day of the week were recorded for the seven years (Table 3).

Hunting pressure thus rises some on Saturdays and greatly on Sundays, but there is a drop in success of 4.6 per cent on Saturdays and 9.8 per cent on Sundays from the Monday-Friday average. One may indulge in not-too-serious speculation whether the slight interruption on Fridays of an otherwise unbroken rise in hunting pressure is related to the widespread superstition regarding the "unluckiness" of Friday. Our only "Friday the 13th" (Dec. 13, 1940) was marked in Missouri by weather no more unfavorable than that preceding and following—yet the amount of quail hunting on that day was the lowest of the season!

TABLE 3.—HUNTING AND HUNTING SUCCESS BY DAYS OF THE WEEK.

	Monday	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*
Total days	48	48	48	41	48	47	49
Total hours hunted	8,700	10,952	11,361	10,111	11,514	13,984	30,066
Averages	181.3	228.2	236.7	246.6	239.9	297.5	613.6
Percentage of total hours	*8.87*	*11.15*	*11.58*	*12.07*	*11.74*	*14.56*	*30.03*
Birds per gun-hour	1.54	1.54	1.53	1.54	1.50	1.46	1.38

Metropolitan hunters are likely to be less well acquainted than other hunters with land and landowners. This leads to several results:

1. Knowing fewer farmers, they find the hunting territory open to them somewhat limited.

2. Knowing less about land and land-use changes, they are in less satisfactory position to appraise the effects of land use upon the distribution of the birds; hence they are more likely to hunt where they have been accustomed to go, even though the birds may have moved elsewhere. For example, during the past three years land use in Missouri has changed markedly and the effect upon the distribution of quail has been equally marked; yet many hunters are apparently unaware of the significance of increased cropping and overgrazing in this regard.

3. Because of the two foregoing facts, and also because their situation does not encourage social intercourse with rural landowners, metropolitan hunters often are unable to visit their intended hunting territory before the season, although this is a common practice among small-town and rural hunters. In other words, city men cannot (or at least, as a general rule, do not) make their hunting as much of a year-round interest as can many others.

Metropolitan hunters and their dogs have limited opportunity for constant practice, because they can go out seldom and must travel far.

It is not a purpose of this paper to suggest ways of overcoming such

obstacles to the full participation of metropolitan hunters in the game program of a state. If the facts are accepted, however, some remedies are likely to suggest themselves.

DECREASE OF QUAIL HUNTING IN MISSOURI, 1938–44

It now seems possible to answer with some assurance the often-asked question: How much has Missouri quail hunting declined during the war years? The matter is presented here because other states may have had similar experiences.

The difference between the hunting pressures in any two years is determined by the relative amounts of hunting by those who hunt during both years, those who hunt during the first year but not the second, and those who hunt during the second year but not the first. The first item can be evaluated by simply totaling the hours of hunting by a fair sample of those active in both years. In normal times, with a fairly constant hunting population, the second and third items would be likely to balance each other; but in wartime the second would be likely to overbalance the first to the extent that men are called into war service.

Of those who hunted during the first of any two war years but not the second, some entered the armed forces, some left the state for other war work, and some were prevented from hunting by other conditions. In Missouri the second group is virtually balanced, as far as we can learn, by the number of men who have entered the state for war work; while the members of the last group report "no hunting" in reply to our regular postcard inquiries. It seems, then, that for a rough estimate of the quantitative effect of the war on quail hunting we need consider only the relative amounts of hunting by those who were active in both of any pair of years and what might be termed the "military loss." Table 4 shows the results of considering *only* the first of these.

In addition to this reduction, however, the military loss was felt from 1941 onward. In evaluating this condition, two assumptions are necessary: (1) Barring military service, these men would have hunted the next year; hence the amount of hunting they did in the first year represents a net loss in the second. (2) The number of our cooperators who entered military service bears about the same relation to the total of our cooperators as the number of quail

TABLE 4.—REDUCTION IN HUNTING BY PERSONS CONTINUING TO HUNT.

Year	*Hunted both this and preceding year*	*Hours hunted*		*Percentage change from preceding year*	*Percentage of 1939 hunting*[a]
		Preceding year	*This year*		
1939	179	8,238	9,189	*+10.3*	*100.0*
1940	197	10,611	9,052	*−14.7*	*85.3*
1941	165	8,329	8,058	*− 3.2*	*82.6*
1942	159	7,790	6,824	*−12.4*	*72.4*
1943	178	7,508	7,525	*+ 0.2*	*72.6*
1944	243	11,293	9,988	*−11.6*	*64.1*

[a] 1939 was the first year in which comparison with a preceding year was possible; it also was the "best quail year" in the 7-year period, and is taken as the basis for comparison.

hunters from Missouri now in the armed forces bears to the total of quail hunters residing in the state—a sort of Lincoln Index. Because the great majority of our cooperators hunt each year—those who drop from the ranks being replaced by new recruits—and because we have a system of postcard inquiry concerning their hunting plans, we believe that both of these assumptions are justified.

Correction of Table 4 to provide for military losses may be made as follows: In each pair of years, add to the first year's hour-total the number of hunters lost between that season and the next *times* the average amount of individual hunting in the first year; then divide the number of hours in the second year by the result. Table 5 shows these corrections.

TABLE 5.—RELATIVE AMOUNTS OF HUNTING, CORRECTED TO SHOW MILITARY LOSS.

Year	*New military loss (hunters)*[a]	*Average hours per hunter, preceding year*	*Added to total hours, preceding year*	*Corrected percentage of preceding year*	*Corrected percentage of 1939 hunting*
1938	0	—	—	—	*90.7*
1939	0	—	—	—	*100.0*
1940	0	—	—	—	*85.3*
1941	1	44.5	44.5[b]	*− 3.8*	*82.1*
1942	17	47.4	806.5	*−20.6*	*65.2*
1943	37	41.4	1,531.5	*−16.7*	*54.3*
1944	4	38.9	155.5	*−12.8*	*47.3*

[a] Total: 59 hunters; these should not be entered cumulatively; each new loss is recorded for the year in which it occurs.
[b] Figures to the nearest half-hour.

The 1944 figure can be tested by comparing 1939 and 1944 directly. A total of 141 men hunted in both years and 59 entered military service between the two seasons. Adding 2,820 hours (=59×47.8, the 1939 hourly average) to the 1939 total of these men (7,085.5 hours) gives a corrected 1939 figure of 9,906 hours. The 1944 figure is 5,186.5 hours, 52.4 per cent of the 1939 figure.

In other words, we may safely say that in 1944 the hunting pressure on Missouri quail was only about half that in 1939. The reductions in 1940 and 1941 were largely due to much poorer seasons. The great decrease associated with wartime conditions came between 1941 and 1943, when the largest number of young men left for military service. Others departed between the 1943 and 1944 seasons, but their numbers were considerably smaller, as attested also by newspaper reports.

It remains only to learn whether this reduced hunting pressure was evenly distributed or manifested more on the 12 "special" hunting days. Table 6 shows the relative hunting pressures and combines them with the total reductions shown by Table 5.

The figures in columns C and D do not, of course, represent any known units. They show only the relative hunting pressures on the special and other days of these years after considering the over-all reduction in hunting pressure during the period. The table reflects three trends: (1) the

general reduction in hunting pressure which has resulted from wartime conditions; (2) a rising tendency to limit hunting to a small number of special days, already shown to have been most marked in the case of the metropolitan hunters; and (3) an increasing disparity between hunting pressures on the special and other days of the season.

TABLE 6.—HUNTING PRESSURE ON 12 "SPECIAL" DAYS AND ON OTHER DAYS. (all figures are percentages)

Year	*Hunting on special days*	*Hunting on other days*	*(A) Average per day, special days*	*(B) Average per day, other days*	*(C) Corrected (A) figures*	*(D) Corrected (B) figures*	*C÷D*
1938	39.9	60.1	3.33	1.50	3.02	1.36	2.22
1939	34.3	65.7	2.86	1.64	2.86	1.64	1.74
1940	46.3	53.7	3.86	1.34	3.29	1.15	2.86
1941	47.5	52.5	3.96	1.31	3.25	1.08	3.01
1942	48.0	52.0	4.00	1.30	2.61	0.85	3.07
1943	48.6	51.4	4.05	1.29	2.20	0.70	3.14
1944	46.4	53.6	3.87	1.34	1.83	0.64	2.86

SUMMARY

1. Metropolitan quail hunters in Missouri, as a group, when compared with hunters living elsewhere in the state, either in general or in only the counties hunted by the former, averaged fewer trips per season, fewer hours afield per season, fewer coveys flushed per day, fewer birds bagged per gun-hour, and a higher proportion of birds shot down but lost during the 7-year period (1938–44).

2. They travelled farther afield and did a higher proportion of their hunting on the 12 "special days" of the season.

3. Their hunting territory was farther reduced during the war years and their hunting was more sharply limited to the special days.

4. Some reasons for these differences in activity and hunting success are discussed.

5. The amount of quail hunting in Missouri has been halved between 1939 and 1944, with relatively heavier hunting pressure on the 12 special days and relatively ligher pressure on the other 40 days.

POPULATION TRENDS AND BLOOD PARASITES OF RUFFED GROUSE IN ONTARIO

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It is well known that cyclical fluctuations in numbers occur among various animals over a period of years. Such a cycle among the ruffed grouse (*Bonasa umbellus*) of Ontario was shown by Clarke (1936). He described a new species of blood parasite, *Leucocytozoon bonasae*, observed in a number of birds taken in 1933 and 1934 when the population was decreasing. He postulated that this parasite might be pathogenic and therefore responsible for the decline.

The ruffed grouse population has again been falling off as revealed in questionnaires collected by the Royal Ontario Museum of Zoology. A survey of the blood parasites in birds collected in October and November 1942 and 1943 has been made and data in the ques-

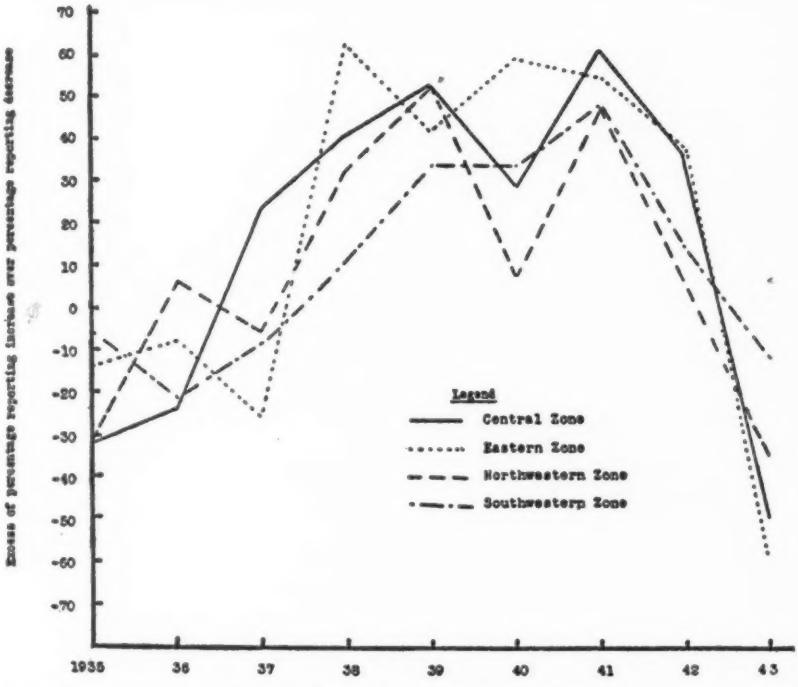


Fig. 1. Trends in population of ruffed grouse in Ontario, 1935–43, according to questionnaire reports received by Royal Ontario Museum of Zoology. Ordinate represents percentage of reports of increase over those of decrease in each year.

tionnaires has been analyzed. More extensive experimental work on the life cycle and importance of these parasites is in progress, but the results here recorded may be useful to others interested in the problem.

The relative abundance of ruffed grouse in various parts of Ontario from 1935 to 1943 (Fig. 1) was plotted from replies to the annual questionnares and represents the difference between the percentages of persons respectively reporting increases and decreases in the number of birds. It reveals, therefore, the trend rather than the actual state of the population. The total number of reports received in the various years is indicated in Fig. 2. The percentage error doubtless is greater in those areas from which fewer reports were received, yet the general trend appears similar in all zones.

Each year a number of individuals reported no change in the grouse population. These reports are included in the total which was used for determining the percentages, and did not affect the general trend of the cycle. A well marked peak of abundance in a single year is not evident. This peak might be expected to occur about 1941, on the basis of Clarke's analysis of data up to 1935, but from the reports received, the birds were abundant in some parts of

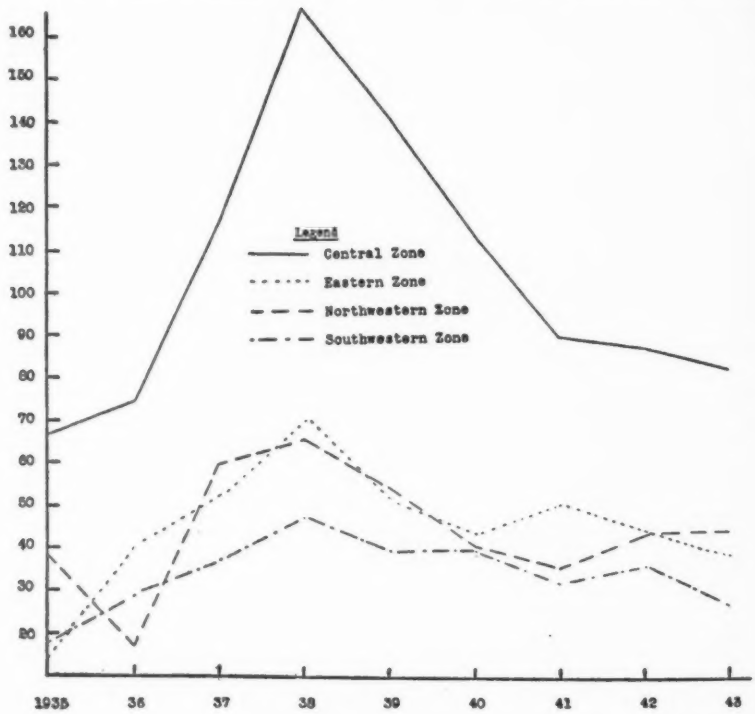
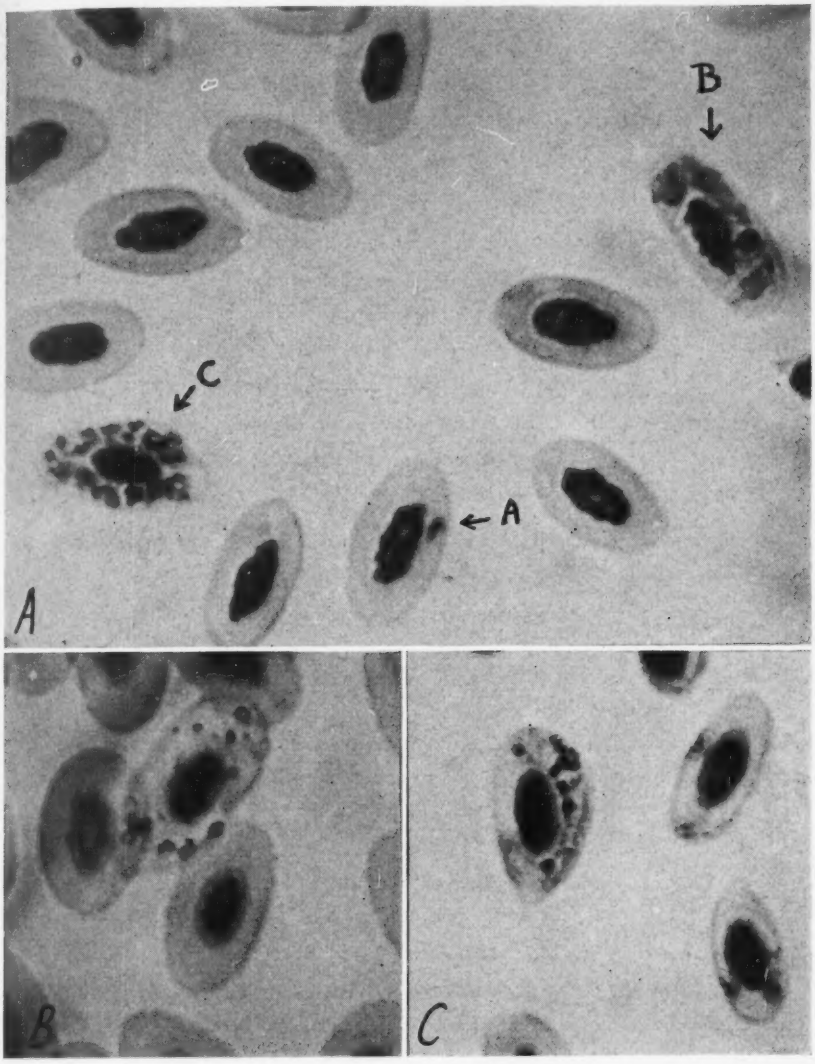


Fig. 2. Number of reports on ruffed grouse received by Royal Ontario Museum of Zoology, 1935–43.



A. Red blood cells of ruffed grouse from Ontario containing stages of *Plasmodium* sp.: trophozoite (A), developing schizont (B), and two schizonts (C) in same cell. *B*. Microgametocyte almost surrounding nucleus of red blood cell. *C*. Macrogametocyte partly surrounding nucleus of red blood cell.

the province as early as 1938 and 1939. No reason was discovered which would account for the decline reported in the northwestern and central zones (of Clarke) during 1940.

The incidence of blood parasites was determined from thin smears made as soon after death as possible; in some there was a delay of 48 hours or more. The smears were stained with Giemsa and examined under high power and oil immersion. Most of the birds studied came from the central part of the province and adjacent areas in the southwestern and eastern zones.

In addition to the blood parasites recorded by Clarke, some birds harbored a species of *Plasmodium* with characters resembling those of *P. circumflexum;* it is highly probable that we are dealing with this or a closely related species. Specific identification of the parasite, however, must await experimental passage to other birds (Huff, *et al.*, 1942). From the stages present in some smears it was uncertain whether the parasite was *Haemoproteus* or *Plasmodium*, or whether stages of both were present.

Other records of malaria in grouse and partridge include those of Laveran and Lucet (1905) and of Böing (1925), who described *P. relictum* from the Hungarian partridge (*Perdix perdix*) and Wetmore (1939) who described stages of a species found in the prairie sharp-tailed grouse (*Pedioecetes phasianellus campestris*) in North Dakota.

Stages of the Ontario species are illustrated in Pl. 9. The trophozoites were round, ovate, lance-shaped or elongate with almost as many of one shape as another. They were polar or sub-polar in position more often than lateral. The schizonts were most frequently elongate in shape and lateral in position and showed a tendency to surround the host cell nucleus. Schizonts with as many as 22 merozoites were observed but more frequently they contained fewer than 20. Division of the nucleus began when the schizonts were relatively small. Gametocytes were elongate and lateral and were frequently curved around the ends of the host cell nucleus or encircled it completely. Pigment granules usually were clumped, often in a single clump, especially in the schizonts. The host cell nucleus was displaced by some parasites but more frequently no displacement was observed.

The elongate character of the schizont and gametocyte, the tendency to surround the host cell nucleus, and the lack of displacement of the latter suggest that the species may be closely related to *P. circumflexum*, but the number of merozoites corresponds more closely with *P. lophurae* Coggeshall (1938). The number of merozoites in the schizonts and the amount of pigment distinguish it from the species described by Wetmore.

The incidence of infection with these parasites in the birds examined in 1942 and 1943 is indicated in Table 1. The infection was light to moderate in most cases, although in a few specimens *Haemoproteus* were present in greater numbers than other species. *Microfilaria* sp., *Trypanosoma* sp., and *Plasmodium* sp., were never found in large numbers. The incidence would probably have been higher if the survey had included young as well as adult birds. This may explain why the incidence and degree of infection was lower than that

TABLE 1.—BLOOD PARASITES IN ADULT RUFFED GROUSE IN ONTARIO.
(51 birds examined in 1942, 55 in 1943)

Parasite	1942 Birds	1942 Infected %	1943 Birds	1943 Infected %
Leucocytozoon	24	47	16	29
Haemoproteus	5	10	1	2
Plasmodium	0	0	0	0
Trypanosoma	1	2	1	2
Microfilaria	0	0	1	2
Plasmodium or Haemoproteus	0	0	3	5
Leucocytozoon + Haemoproteus	4	8	7	13
Leucocytozoon + Microfilaria	1	2	2	4
Leucocytozoon + Trypanosoma	0	0	1	2
Leucocytozoon + Plasmodium	1	2	3	5
Leucocytozoon + Plasmodium or Haemoproteus	1	2	4	7
Leucocytozoon + Microfilaria + Trypanosoma	0	0	1	2
Leucocytozoon + Microfilaria + Plasmodium	0	0	2	4
Leucocytozoon + Trypanosoma + Plasmodium	0	0	2	4
Totals				
Leucocytozoon	30	59	37	67
Haemoproteus	9	18	8	14
Plasmodium	1	2	6	11
Trypanosoma	1	2	5	9
Microfilaria	1	2	6	11

recorded by Clarke in 1933 and 1934. Nevertheless the number of different blood parasites observed in these birds is remarkable and raises the question at once as to whether any are of pathogenic significance.

Dr. H. B. Speakman, Director, Ontario Research Foundation, made this work possible and gave kind encouragement and advice; Professor J. R. Dymond and Mr. L. L. Snyder gave permission to use data in their questionnaires; Mrs. Godson and Mr. S. Downing assisted extracting the data; and Mr. D. J. Taylor, Deputy Minister of Game and Fisheries, arranged to have a number of birds sent in for examination.

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ADAPTABILITY OF THE CHUKAR PARTRIDGE TO MISSOURI CONDITIONS[1]

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The chukar partridge (*Alectoris graeca chukar*) was introduced into Missouri in 1934 when the Windsor Game Farm, operated by the Game and Fish Department, purchased two pairs and an extra cock from a California breeder. There then was considerable interest in chukars in Missouri, and the Department planned to raise enough for an extensive stocking program. When the new Conservation Commission was established in 1937, there were approximately 1,000 chukars on hand, all descendants of the original pairs. Their disposal was referred to the newly-established Missouri Cooperative Wildlife Research Unit.

Ordinarily neither the Commission nor the Research Unit would have been interested in such a problem, but the birds offered an opportunity to study experimental releases and the establishment of the species, should the latter occur. With the cooperation of associated departments in the University of Missouri, a study was planned of the life history, ecology, diseases, hatchery techniques, management, and adaptability of the species. The writer made the field investigations, with general assistance from Dr. Rudolf Bennitt of the University of Missouri and Dr. Paul D. Dalke of the U. S. Bureau of Biological Survey. The study began in September 1937.

There were several initial justifications for the work: the available birds represented a considerable investment; they had received a good deal of publicity and sportsmen were interested; elimination of the ruffed grouse, prairie chicken, and wild turkey from most of their former ranges had left vacant niches which might possibly be filled by the exotic species; and there was an excellent opportunity to study the factors determining the success or failure of an apparently desirable exotic game bird, propagated artificially and released on Missouri range. Finally, if the birds were to be used, there was need to establish them under a system that would permit control if they became undesirable.

The detailed life-history study was brief because the birds released in 1937 and 1938 tended to wander in widely-scattered groups. This was disadvantageous in two ways: They refused to settle down, so their range preferences could not be learned, and in no place were they sufficiently numerous to provide adequate data.

By the end of the first year, one possible justification for their introduction had largely disappeared. With recovery from the 1934–36 drought and the use of changed farming practices, prairie chickens and bobwhite quail increased to where the latter were abundant on almost every type of range and the

[1] Contribution from Missouri Cooperative Wildlife Research Unit. U. S. Fish and Wildlife Service, American Wildlife Institute, Missouri Conservation Commission, and University of Missouri cooperating.

former were re-occupying range formerly vacant. The organization of a wild-turkey study by the Research Unit aroused hopes that this species also might be restored to a large part of its former range. In short, the legitimate place of chukars in the Missouri game picture became questionable. The

Finally, inquiry into the background of our chukars disclosed that of the 22 subspecies of *A. graeca* living in a variety of Eurasian conditions, the Missouri stock probably was the subspecies most unsuited for introduction into the state because of the wide differences between the native and new ranges. On

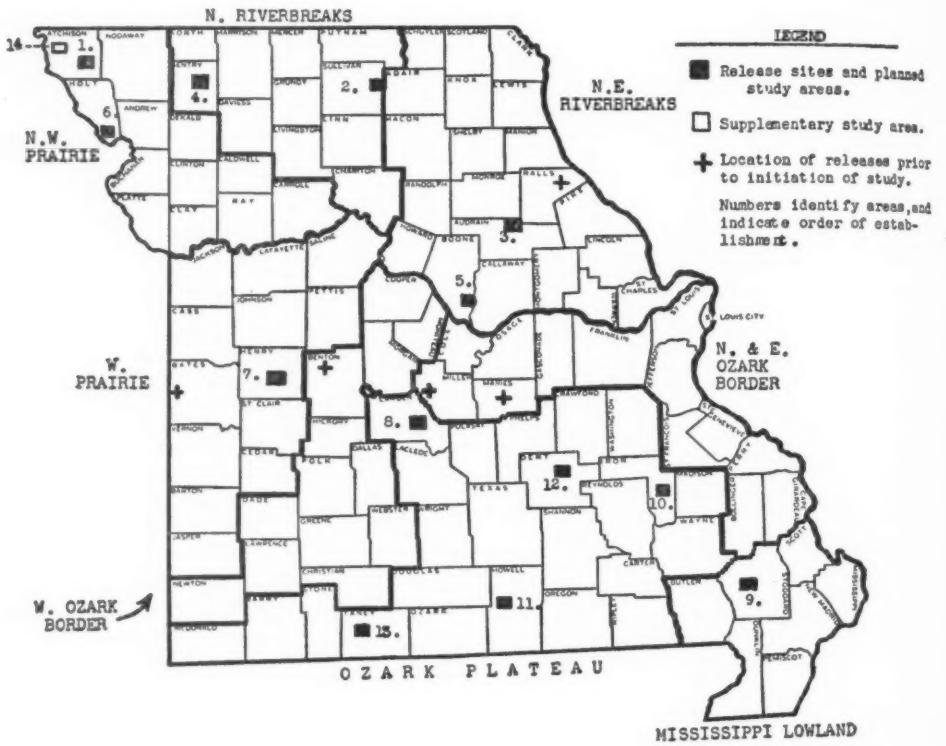

Fig. 1. Distribution of study areas and sites for chukar partridge in Missouri.

Commission's policy of emphasizing restoration of native game by natural means led to discontinuance of the game farm where chukars had been propagated. Since no more bobwhite quail were to be reared, the farm could not be justified merely for a few hundred chukars each year.

tracing the Missouri birds through the Smith Game Farm at Fair Oaks, California, to the original exporter in Calcutta, it was learned that they had been netted in the mountains of Nepal, at altitudes of 6,000 to 10,000 feet. Other subspecies inhabit regions more nearly comparable to Missouri in altitude,

weather, and land-use. Our problem, however, was not to select the most desirable subspecies, but to make use of the birds at hand.

In December 1938 intensive life-history studies were discontinued until the birds should become established; those remaining on hand were released in the spring of 1939. This was to be the final release unless the course of events prsented need for additional releases,

The following practical objective were sought: (1) To learn whether establishment would result from releases already made; (2) to watch for evidence of competition between chukars and native species; (3) to evaluate the chukar as a desirable game bird; and (4) to gather such life-history data as opportunity permitted.

RELEASE AREAS

To test the relative suitabilities of various combinations of climate, topography, and land-use areas for release were selected in every major land type in the state (Fig. 1), as follows:

1. Five in the four zoogeographic regions of northern and western Missouri, the major original range of the prairie chicken.

2. Five in the Ozarks, the major original range of the wild turkey and ruffed grouse.

TABLE 1.—SCHEDULE OF CHUKAR PARTRIDGE RELEASES.

Area No.	County	Autumn 1937	Spring 1938	Autumn 1938	Spring 1939	Totals
1	Atchison	50	—	—	30	80
2	Sullivan	50	50	—	82	182
3	Audrain	50	50	100	100	300
4	Gentry	50	50	—	90	190
5	Boone[a]	50	—	50	—	100
6	Holt[b]	—	50	—	—	50
7	Henry	50	50	100	100	300
8	Camden	50	50	50	50	200
9	Stoddard	50	—	—	—	50
10	Iron	50	50	50	—	150
11	Howell[c]	56	50	—	—	106
12	Dent[d]	50	—	—	—	50
13	Taney[c]	—	50	—	—	50
14	Atchison[e]	—	—	—	30	30
Totals		556	450	350	482	1,838

[a] Univ. Missouri Wildlife Experimental Area.
[b] Squaw Creek Migratory Waterfowl Refuge.
[c] Forest Service refuges.
[d] Indian Trail State Forest.
[e] Selected when a group of birds from Project 1 temporarily established themselves in a new location of different type.

3. One in each of the two principal marshy regions in the Mississippi Lowland and the Missouri River bottomlands of the northwest.

4. One in the Ozark Border, to compare with results from two earlier releases. Where more than one area was located in a zoogeographic region, a wide contrast in land types was sought.

The study offered opportunity for cooperation between farmers, sportsmen's groups, and the Conservation Commission; some areas were sponsored by local farmers' groups, others by sports-

men working with farmers, and five by state or federal agencies. In all cases written agreements provided for protection, observation, and aid in management. The Commission posted the areas as Cooperative Wildlife Management Projects, and exercised close protective supervision.

PROGRAM OF RELEASE

From 50 to 100 birds were released at each stocking of each area, in one or several groups. All were marked with acetone-sealed celluloid bands to indicate the season and location of release (Table 1).

The first plan was to release the same total of birds on each area, but Projects, 6, 9, 11, and 14 soon proved unsuitable, since no birds remained; and after the initial stocking none was released on Project 12 when that became a turkey management area. The remaining chukars were released on the areas still active and in numbers based on apparent chances of establishment.

At the end of the two-year stocking program, the average density of released partridges on the eight active areas was one per seven acres.

MORTALITY

Of 1,838 birds released, 123 were found dead; 78 (63%) had died within two months after release. The causes of mortality were as follows:

Predators:		85
Fox	20	
Hawks	22	
House cat	17	
Dog	6	
Horned owl	6	
Raccoon	1	
Weasel	1	
Unknown	12	
Disease		14[a]
Accident		13[b]
Shooting		3
Unaccounted		8

[a] Coccidiosis, probably complicated by physiological upset accompanying release.

[b] One drowned in watering trough; 2 trapped in old well; 2 flew into obstacles; 2 run over by vehicles.

Information on predation was obtained in the field for all but two birds: Laboratory examination of one disclosed the fang of a pit viper in the breast muscles, and skinning another revealed tooth-marks of a weasel in the throat and breast. When remains were found in the field, examination of tooth-marks, parts eaten, and nearby "sign" (tracks, pellets, scats, hair, or feathers) indicated the predator. Paul L. Errington helped in identifying the predators. In three cases, involving a red-tailed hawk, a dog, and a house cat, respectively, the act of predation was witnessed.

The 63 per cent of deaths soon after release indicated high susceptibility during that period, as might be expected. Only four of the dead were young birds reared in the wild, although 1,503 had been produced, indicating high resistance of wild-reared birds to predation. The effects of disease may have increased the vulnerability of the released stock to predation. These birds also were quite tame and for several days showed little inclination to avoid either persons or animals; they were easily confused, since their escape-reactions for a week or two seemed haphazard and inefficient. Nevertheless, the birds reared in the wild suffered little detectable predation and were wild enough to escape by refusing to permit close approach and by concealing themselves quickly.

RANGE PREFERENCES

The chukars actually increased for a time on one area and abandoned some types more promptly than others. The order of abandonment was as follows:

1. Marshlands and areas largely wooded, including the Ozark Plateau and Borders and the post-oak lands of the Northeastern Riverbreaks (Projects 2, 5, 6, 8, 9, 11, 12, and 14). None was observed on these areas during the summer of 1940, although 982 of the 1,838 birds were released there.

2. The predominantly open areas of the Northwestern, Western, and Northeastern Prairies and the broad valley farmlands of the Ozarks (Projects 1, 3, 7, and 10). The surviving population of 64 birds in the autumn of 1940 represented 7 per cent of the 860 released there and 23 per cent of the total recorded survival.

3. The farmed slopes and wooded draws of the Northern Riverbreaks (Project 4). The 1940 autumn population of 216 birds amounted to 114 per cent of the 190 released there and 77 per cent of the total recorded survival.

COVER REQUIREMENTS

The differences noted above were largely associated with differences in cover preference. The chukars used neither extensive wooded areas nor open prairie. They were found variously along fencerows and the edges of woodland, in field borders, in narrow draws containing trees, brush, grass, and forbs, in fields with short cover such as low forbs, grasses, brush, grain, and hay crops—in short, in the kinds of cover resulting from mixed land-use. This also is the sort of cover most favored by bobwhite quail, except that the latter are more tolerant of forest conditions.

Specific cover types used by chukars were as follows:

Nesting cover. Tall herbaceous or mixed herbaceous-shrubby cover. The nests were shallow excavations in the ground, of the general dimensions of a soup-plate, lined with coarse grass or fine twigs, and well-concealed by vegetation on all sides and above. They were usually situated at the bases of rocks, shrubs, or clumps of grass. The writer found 18 nests before learning that despite precautions (as to close approach or disturbance) all were subsequently destroyed by predators. Since successful nesting was deemed more important to the study than detailed nesting data *per se*, the search for nests was abandoned.

Roosting cover. Usually small cleared spaces covered and surrounded by concealing vegetation, debris, rocks, or man-made structures were used. Those affording perches such as logs, rocks, roots, brush piles, and branches on or near the ground were used most frequently. One group of birds habitually roosted during cold weather on the roof of a farmhouse porch against the side of the building. In roosting, the birds did not group themselves in any definite pattern as quail do, but often were distributed over an area of several square feet, depending on the size of the chosen location.

Escape cover. No particular cover-type seemed to be selected for escape. The birds used almost any nearby cover sufficiently high and dense to hide them. When alarmed they did not habitually go at once toward dense cover, particu-

larly if surprised in the open; most frequently they "froze" on the spot, especially if suddenly approached. Each bird immediately stood motionless; then, slowly and almost imperceptibly, it sank to the ground, gradually turning on one side so that the brown breast-stripes were partly exposed and uppermost. No matter what the background, it appeared almost invisible, and photographs of birds in this position fail to distinguish them clearly. When the danger was apparently past, the bird made a cautious, gliding run into the nearest cover. Once in grassy or herbaceous cover, chukars were seldom rediscovered because they again "froze", this time in surroundings affording much better concealment.

Feeding cover. Chukars apparently fed wherever they chose, regardless of cover, except that no birds were seen feeding more than 50 yards from some form of cover.

Travel cover. Chukars on the move, especially the wandering coveys discussed below, followed fencerows, roadsides, and field- and woodland-borders wherever possible, moving along the edges of cover but seldom through it if the growth was at all dense.

FOOD HABITS

Chukars in the field were seen to eat seeds of ragweed, Korean lespedeza, foxtail, sorghums, corn, oats, and wheat, and also the green leaves of bluegrass, clovers, lespedeza, and wheat. One hen plucked the seed-heads of dandelions, then in successive bites clipped the stems down to the ground. Frequently the members of a covey were seen chasing grasshoppers or scratching through leaves, snow, and litter in search of other insects. During the spring and summer, feeding chukars did not seem to keep to any particular territories or to avoid territories of other birds. Whenever they trespassed upon the mating grounds of other birds, however, any aggressiveness by the latter caused the chukars to retreat. The writer has seen them driven away by robins, brown thrashers, killdeers, quail, prairie chickens, catbirds, migrant shrikes, and even Bewick wrens. At other times of year, however, chukars and other species fed together peaceably.

TABLE 2.—FOOD MATERIALS IN 228 DROPPINGS AND 8 CROPS OF CHUKAR PARTRIDGES.

(All figures are percentages: A, of the total samples containing the food listed; B, of the food in the individual sample.)

Food	*Droppings*		*Crops*	
	A	*B*	*A*	*B*
Green matter, grass and fibers	100	77	87	16
Grit	90	1	75	33
Ragweed[a]	42	12	50	26
Insects[b]	32	12	37	43
Corn	26	8	25	11
Unidentified seeds[c]	26	2	12	0
Korean lespedeza	21	1	25	15
Oats	21	27	0	0
Sorghum cane	10	18	0	0
Soybeans	0	0	12	1
Smartweed	0	0	25	7
Foxtail	0	0	12	68

[a] Mostly *Ambrosia trifida;* some *A. bidentata.*

[b] Mostly grasshoppers, some ants, beetles, and pill-bugs (Crustacea).

[c] Unidentifiable remnants of seeds and leaves.

Droppings, 228 in all, were gathered from chukar roosting sites and the crops were removed from eight dead birds. The few data from these merely indicate the general diet of the species (Table 2).

Upon release, few chukars seemed to recognize available food. Six weeks be-

fore the last were set out (spring, 1939), the regular hatchery ration of pellets and mash was replaced by scratch grains and alfalfa-leaf meal. When the latter birds were released, they immediately began to scratch about for food, to pick at seed-heads of Korean lespedeza and sorghum cane, and to clip green wheat shoots. This brief test suggested the desirability of "preconditioning" birds for release by offering them foods more nearly like those to be encountered in the wild.

In general, the food and cover requirements of chukars in Missouri seem much like those of bobwhite quail. Chukars do not adopt a restricted cover-area for winter residence and tend to avoid woodlands. Otherwise, the two species apparently have requirements enough alike to indicate possibility of competition, should chukars increase sufficiently in number.

REPRODUCTION

The chukars paired in February and March, with energetic but practically bloodless fighting among the cocks. With the break-up of a covey in February, mated pairs scattered seemingly in search for nesting sites and some were still moving about in April. The pairs scattered widely; the highest concentration was of three nests on 80 acres in Project 7. Eggs were found between May 5 and August 11; there was no indication of renesting.

The hen did all the incubating, leaving to feed for not more than one-half hour in early morning and late evening. The cock acted primarily as a sentry, perching on a convenient post or elevation, and giving warning calls at the approach of man, livestock, dogs, or large birds. When an observer approached too closely the cock acted as a decoy, simulating a wounded bird, and making off away from the nest. Fighting continued during the nesting period when unmated males ventured near a mated cock.

From 2 to 19 eggs were found in the nests examined and the incubation period probably coincided with that at the hatchery—21.5 days. The young hatch, like quail, "on the run," leaving the nest at once. They have been seen catching grasshoppers when only two days old.

The average number of young produced was 14.6 per pair by 13 pairs under close observation on Project 4. The only adults on the areas during the summer were those engaged in nesting and a few unmated cocks. Production of young on the active areas during the three nesting seasons is shown by Table 3.

The average ratio of productivity was highest following the 1939 spring release, for which three factors may have been responsible: (1) the cumulative effect of the survival of only the best (most adaptable) birds from previous releases; (2) release of the 1939 birds just before the breeding season, so a larger proportion may have nested; and (3) "preconditioning" of those birds by the procedure mentioned above.

The total of young (257) produced in 1940, added to the number of adults found (21), gives the number (278) known to have survived on and near the project areas at the time of the last count, October 1940. Due to the secretive nature of the birds, especially when with their young, and to the extent and density of fall cover, it is

likely that continued investigation would have disclosed additional coveys.

The ratios of young produced to adults released are significant in that no ratio has been high enough to indicate successful establishment. Even on Project 4, where about 2.5 birds were produced to every one released, the rate of production is probably not high enough to compensate for losses through natural mortality and wandering, without constant replenishment by additional releases. This is not to say that chukars are low in productivity; the ratio of young produced to adults actually engaged in nesting was high, as illustrated by the average of 14.6 young per pair on Project 4. However, not enough birds remained and nested on the areas to insure production sufficient for any substantial annual increase, and there have been no subsequent reports that this occurred anywhere else.

TABLE 3.—PRODUCTION AND RELEASE OF CHUKAR PARTRIDGES IN MISSOURI. (R, young produced per bird released.)

Area No.	1938			1939			1940	Totals		
	Birds released	Young produced	R	Birds released	Young produced	R	Young produced	Releases	Production	Average R
1	50	64	1.28	60	43	0.72	0	110	107	0.97
2	100	28	0.28	82	50	0.61	0	182	78	0.93
3	200	44	0.22	100	181	1.81	4	300	229	0.76
4	100	167	1.67	90	130	1.45	190	190	487	2.56
5	100	28	0.28	0	12	—	0	100	40	0.40
6	50	12	0.24	0	0	0	0	50	12	0.24
7	200	37	0.18	100	329	3.29	46	300	412	1.37
8	150	50	0.34	50	0	0	0	200	50	0.25
9	50	0	0	0	0	0	0	50	0	0
10	150	12	0.08	0	49	—	17	150	78	0.52
11	106	0	0	0	0	0	0	106	0	0
12	50	0	0	0	0	0	0	50	0	0
13	50	10	0.20	0	0	0	0	50	10	0.20
Totals and averages	1,356	452	0.34	482	794	1.65	257	1,838	1,503	0.82

SURVIVAL AND WANDERING

In October 1940 it was possible to account for 278 chukars on and near the project areas, but this does not mean that all of the remainder of the 1,838 released and the 1,503 they produced were dead. Both released and wild-reared birds left the areas in coveys. Some wandered so far that they were lost to observation, but not all were killed as 38 coveys were rediscovered variously at 4 to 65 miles from the points of release. Some of these settled long enough to nest, and 17 broods reared by wanderers were observed for short periods before the birds moved on again. By December 1939, however, the locations of only 3 groups were known; the rest had escaped observation.

Since their secretive behavior permitted so few wandering coveys to be found, it is almost certain that more young were reared than recorded. Some

apparently reliable reports of hitherto unrecorded coveys were received after conclusion of the study, the latest in the autumn of 1944 from near Project 4. The demonstrated tendency was for continued wandering and progressive attenuation of the population; hence the likelihood of establishment, which never was strong, decreased every year after the last release. So long as one breeding pair remains in the state, however, there is possibility of eventual establishment.

RELATION TO NATIVE SPECIES

There was no evidence that chukars interfered directly with any native species. Because of their similar habits, chukars are most likely to be closely associated with bobwhite quail. On several occasions the two fed together in the winter, but never for more than a day or two. Chukars apparently were intimidated by the presence of quail; in every instance where a covey of chukars was seen to enter quail cover, the former left in a day or two and the quail remained. In two such cases both species evinced considerable uneasiness, but there was no fighting. Should the chukars increase to anything like the abundance of quail, competition for food probably would result because a chukar weighs three times as much as a bobwhite.

GAME QUALITIES

Experiments in working dogs on chukars were not always successful but indicated that, with experience, many bird dogs could handle the birds well. Wing-shots would be rare in hunting unless the dogs could hold the birds until flushed, and even then the birds probably would run away much of the time. Because of the ability to conceal themselves and to slip away unnoticed before a close approach could be made, chukars would exasperate hunters not used to a high degree of "escapability" in their intended prey. The table quality of chukar meat reportedly is high; the meat is white, and a well-grown bird averages 1.5 pounds. The flavor is esteemed by those who hunt chukars in their native habitat, and one local report (not the writer's) confirms this opinion.

DISEASE

A. J. Durant, Department of Veterinary Medicine, University of Missouri, studied diseased birds from the field and hatchery, made experiments in exposing chukars to diseases of other game birds and of poultry, and tested the effects of dietary variations on susceptibility to disease.

Chukars proved susceptible to the common diseases and parasites such as ulcerative enteritis (contractible from quail), blackhead (from ground traversed by diseased turkeys), coccidiosis, trichomoniasis, caecal worms (*Heterakis* sp.) and other roundworms, and capillaria worms. They were not nearly as susceptible to ulcerative enteritis as are quail, but a combined infection of blackhead and coccidiosis proved particularly lethal.

The writer found that farmers on Project 3 had fed poultry infested with helminth and coccidia a scratch-grain mixture rich in cane seed, believing that such diet had both preventive and curative effects. As a test, a group of chukars was fed a similar diet while on infected grounds, but they showed no increased resistance to infection.

SUMMARY

1. The Missouri chukar partridge was identified as *Alectoris graeca chukar*, the Indian Hill Partridge. The varieties, plumage changes, and life-history, are given by E. C. Stuart Baker, "The Game Birds of India, Burma, and Ceylon," Jour. Bombay Nat. Hist. Soc., 28 (2), 1922.

2. Loss of chukars after release through predation and disease was not enough alone to constitute a deciding factor in establishment.

3. The available food seemed adequate to keep chukars in good condition but items essential to the establishment of a high population may have been missing. Cover seemed adequate for protection and travel but nesting cover may have been deficient as indicated by the low density of nests even on areas apparently most suitable.

4. Production of 14.6 young per nesting pair, as on Area 4, would insure population increase, but was rendered inadequate by associated factors, primarily the habit of wandering.

5. Most of the birds reared or released left the areas, scattered widely, and continued to move without settling; whatever the cause(s), this dispersal was primarily responsible for failure of the birds to become established. This was particularly true on Area 4, where productivity was high and mortality low, but the eventual result was decrease and abandonment.

6. Chukars proved susceptible to common diseases of poultry and game birds.

7. It early became apparent that chukars, if established, would be in localities also favorable to bobwhite quail. Similarity in food habits of the two suggested that chukars, in abundance, would compete strongly with quail for food. This was the greatest factor influencing the decision to cease releasing chukars when the stock on hand was exhausted.

8. In view of the relatively low mortality and good productivity, if chukars had remained on the areas in numbers approaching those released, they probably would have become established in some places. Not enough of the birds remained on the areas, probably because of some environmental deficiency in the kind, quantity, quality, or arrangement of food and cover, or to some peculiarity of the birds themselves. Conditions were unsuitable for establishment of pen-reared Indian Hill Partridges in Missouri, by releases averaging one bird per seven acres.

RESISTANCE TO HUNGER IN BIRDS

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Ability to tolerate periods when food is scarce or unobtainable is of utmost importance to birds, especially in the winter when air temperature may also be low. Hunger becomes more quickly critical at low air temperatures because general metabolism is higher and more energy is required to maintain constant body temperatures. Small wild birds do not feed during the hours of darkness, and in winter the nights may be too long and too cold for some species to survive. Thus, the capacity of different species to survive for periods without food is important in controlling their migration, distribution, and abundance (Kendeigh, 1934).

There have been few studies to date on the survival time of wild birds without food as affected by air temperature. Terroine and Barthelemy (1922) starved pigeons and a small 15-gram European species, *Vidua principalis*, at 6.5°, 20°, and 38°C.; they found that the survival period was longer at higher temperatures and that the decrease in weight before death was also greater. Kendeigh (1934) conducted a study that covered a range of temperatures from −15° to +40°C. and which involved the English sparrow and the house wren (*Troglodytes aedon*). Errington (1939) tested the relative resistance to hunger under variable outdoor temperatures of the bobwhite quail and ring-necked pheasant. More recently, Gerstell (1942) has reported on the survival time of nine large species at a constant temperature of −18°C., at room temperatures varying from about 1° to 10°C., and under variable outdoor temperatures.

Experimental Procedure

Since our earlier studies showed seasonal variation in the ability to resist hunger, all experiments in the present investigation were limited to the winter. Some 137 English sparrows (*Passer domesticus*) were worked with from December to early March. Each bird was placed in a small separate cage of hardware cloth, all experiments were conducted in total darkness, and the birds were left undisturbed except when observations were made. Water was not offered because preliminary experiments showed that the birds either did not drink in the darkness or, if they did, the water did not prolong their survival period. Time of death was figured as midway between the last time the bird was observed alive and the time it was found dead. This time was determined within a few minutes in the cases where the survival periods were short, and with the longer survival periods the possible error seldom exceeded 10 per cent of the total time involved.

Birds were used immediately after removal from the traps where they had recently been feeding. No birds were ordinarily started in an experiment in the morning as their survival time then is shorter than if started in the afternoon. Each bird was weighed at the beginning and end of the experiment. Exceptions to the usual procedure were a few birds whose periods of tolerance were

determined along with their rates of metabolism at extreme temperatures (Kendeigh, 1944).

Air temperatures were held constant within 1° to 2°C. over a range from −40° to +45°C. through the use of special temperature cabinets, refrigerators, incubators, and rooms, all under thermostatic control. Air temperatures were recorded either by maximum-minimum thermometers or by self-recording potentiometers using thermocouples. Ventilating fans insured adequate circulation of the air.

SURVIVAL TIME WITHOUT FOOD

All data on survival time without food are incorporated in Fig. 1 with indication of the sex and initial weights of the birds. There obviously is a wide scattering of points and considerable individual variation, but a line has been drawn through the data to show the general trend of variations. Certain considerations entered into the drawing of this line. Only birds with normal initial weights of at least 27 grams were used. An average and a median value were determined for each five-degree interval of temperature. The median was arrived at by alternately striking out the highest and lowest values until only one remained. The average and median values fell close together except between 20° and 35°C. where the median values indicated a peak at 29°C., while the averages showed a plateau. These values were temporarily plotted and a line drawn between them to the best apparent fit.

The curve shows that with a decline in air temperature from 29° to 10°C., there is rapid decline in ability to resist starvation, averaging two hours for each drop of one degree. From 10° to −40°C., the decrease in survival time is slower, averaging only one-half hour per degree. From 29° to 46°C. the decrease in survival time is very rapid, averaging four hours per degree. At 46°C., survival time is practically zero, but at −40°C., the birds are still capable of about five hours survival.

Differences in activity were probably responsible for much of the individual variation. As previously shown (Kendeigh, 1934), birds kept in continuous light, which encourages restlessness, do not live as long as those kept in darkness, where they normally are quiet. Phillips, Ashworth, and Brody (1932) also found that the temperament of the individual affected its ability during starvation to remain quiet and to conserve its dwindling energy supply.

WEIGHT AND SURVIVAL TIME

Over most of the temperature range, heavier birds live longer than individuals of lesser weight (Fig. 1). Averages of the data on all birds show this to be true at all ranges of temperature from −19° to +35°C. (Table 1). Below −19°C., any effect of differences in weight is obscured by discrepancy in the average temperature at which the experiments were performed. Above 35° C. the number of records is too small to show any certain influence of weight.

More records of females than males fall below the curve, indicating shorter survival by females than the average for the species; records of males predominate above the curve. The average weight of the males used, however, was 1.5 grams greater than of the females and the difference in survival time

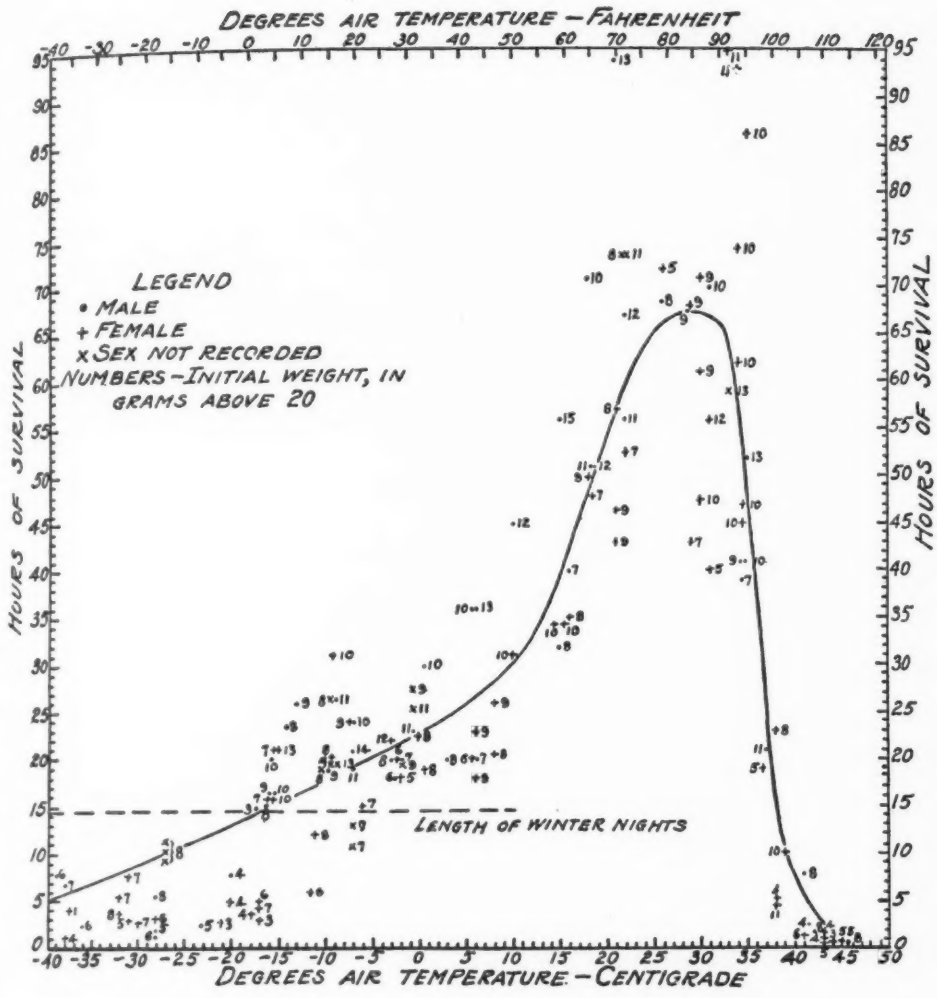
DEGREES AIR TEMPERATURE — FAHRENHEIT
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120
LEGEND
• MALE
+ FEMALE
x SEX NOT RECORDED
NUMBERS — INITIAL WEIGHT, IN GRAMS ABOVE 20
LENGTH OF WINTER NIGHTS
HOURS OF SURVIVAL
HOURS OF SURVIVAL
DEGREES AIR TEMPERATURE — CENTIGRADE
-40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50

Fig. 1. Variation in survival time without food by English sparrows at different temperatures.

doubtless was due to this factor and not to sex as such. A sex difference in weight during the winter also obtains under natural conditions. The weights for 80 males, taken immediately after removal from outdoor traps, averaged 29.5 g., and 74 females averaged 28.4 g. No sexual difference in rate of metabolism has been found for the English sparrow (Kendeigh, 1944).

TEMPERATURE AND LOSS IN WEIGHT

The normal initial weights of birds subjected to starvation showed random

variation around 29.4 g., but the final weights of the same individuals at death decreased progressively from 26.3 g. at −31.5° to a minimum of 19.0–19.7 g. between +21° and +35° and rose again to 26.0 g. at 42.8°C. weights) increased by 0.14 g. per degree of rise in temperature from −35° to +34°C. and decreased 1.06 g. per degree from 34° to 43°C. (Fig. 2). In percentage of initial weight, the total weight loss at death ranged from 5 per

TABLE 1.—COMPARATIVE SURVIVALS OF BIRDS OF TWO WEIGHT GROUPS IN EACH RANGE OF TEMPERATURE.

Temperature		Number of birds	Survival time, hours	Initial weight, grams	Final weight, grams	Total weight lost, grams	Weight loss per hour, grams
Range °C.	Average °C.						
−39 to −30	−32.6	5	5.3	27.0	26.1	0.9	0.18
	−36.3	5	3.7	24.5	23.6	0.9	0.23
−29 to −20	−26.8	4	3.2	26.2	25.3	0.9	0.28
	−22.2	4	4.4	23.9	22.7	1.2	0.27
−19 to −10	−14.3	10	18.5	29.4	24.9	4.5	0.25
	−14.8	10	11.3	25.8	22.9	2.9	0.30
− 9 to 0	− 5.1	12	23.5	30.9	25.2	5.7	0.24
	− 4.5	11	18.5	27.1	23.5	3.6	0.19
+ 1 to +10	+ 6.4	6	33.5	30.9	23.4	7.5	0.22
	+ 5.3	6	20.9	27.6	23.2	4.4	0.21
11 to 20	16.7	6	49.5	31.3	22.4	8.9	0.18
	16.7	5	41.0	28.0	21.0	7.0	0.17
21 to 30	26.1	9	67.2	30.4	19.5	10.9	0.16
	23.5	8	57.0	27.6	18.8	8.8	0.15
31 to 35	33.5	7	66.0	31.5	19.9	11.6	0.18
	33.6	8	54.8	28.7	19.1	9.6	0.18
36 to 40	38.0	3	11.8	30.7	25.9	4.8	0.41
	37.4	2	21.0	26.8	21.4	5.4	0.26
41 to 45	42.8	3	1.0	27.2	26.4	0.8	0.80
	43.8	4	0.5	24.8	24.5	0.3	0.64

The lowest weight of any bird at death was 15.7 g.; this was a female that survived 72 hours at 26°C. despite an abnormal initial weight of only 24.9 g. In general, final weights tended to vary inversely with survival time.

Considering only birds with normal initial weights of at least 27 g., the total weight loss at the time of death (difference between the initial and final cent at −32° and 6 per cent at +43° to 36 per cent at +34°C. On the other hand, the curve showing the rate of weight loss per hour varied inversely (Fig. 2). The two values for weight lost per hour at about −30°C. are out of line but are based on too few records to have much significance. The turning point in the curve for weight loss per hour probably is at 29° rather than at

34°C. Increase in survival time without food is thus definitely correlated with ability to lose more body weight before death and to lose this at a slower rate.

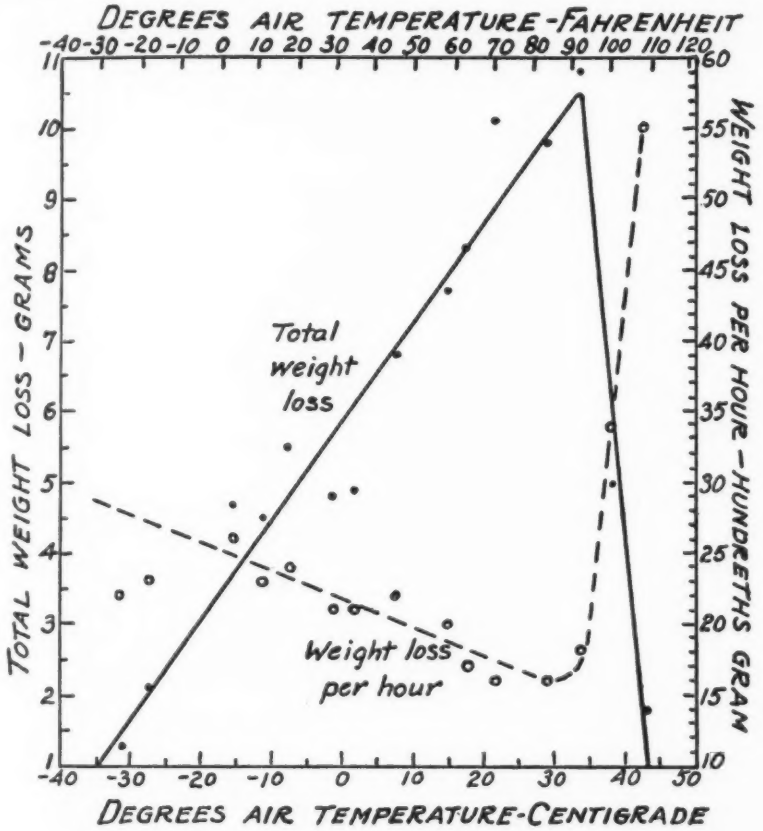
DEGREES AIR TEMPERATURE-FAHRENHEIT
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120
TOTAL WEIGHT LOSS - GRAMS
WEIGHT LOSS PER HOUR - HUNDRETHS GRAM
Total weight loss
Weight loss per hour
-40 -30 -20 -10 0 10 20 30 40 50
DEGREES AIR TEMPERATURE-CENTIGRADE

Fig. 2. Variations in weight lost by English sparrows without food at various temperatures.

When the weights at death of heavier and lighter birds are compared, it is apparent that in separate ranges of temperature (Table 1) between +1° and +35°C. the final weights of the two groups are close. The average difference was 3.0 g. in initial weights, and only 0.8 g. in final weights. Between 0° and −19°C., however, the difference in initial weights averages 3.7 g. and in final weights 1.8 g., while below −19°C. and above +35°C., the average differences in initial and final weights between the two groups is nearly identical 2.8 and 2.9 g. respectively. Only at moderate temperatures do the heavier birds approach close to the basic weight which the lighter birds attain at death.

WEIGHT LOSS AND CAUSES OF DEATH

Previous work (Kendeigh, 1944) has shown that energy utilization during

starvation is primarily at the expense of body fat. Oxidation converts the fat into carbon dioxide and water. The weight of carbon dioxide lost in respiration may be disregarded as it is almost exactly balanced by that of the oxygen absorbed. The decline in weight by a bird during starvation results not merely by loss of water derived from the oxidation of fats, but also by urinary wastes from the kidneys and, at least, at high temperatures, by additional water drawn from other body tissues. Water is lost both in the expired air from the lungs and in the excrement that continues to be voided.

Only between 21° and 35°C. does the loss of weight indicate that the fat reserves are being utilized to the maximum so that death results from actual starvation. At lower temperatures death apparently occurred before the fat reserves were completely exhausted. The higher hourly rate of weight loss at low temperatures agrees with the higher rate of metabolism required to maintain body temperatures. However, there is inability to maintain these increased rates over a long enough period to exhaust the potential energy reserves. The heavier birds experience the same difficulty as the lighter birds, but maintain an advantage in being able to mobilize more reserve energy, at least until temperatures become extreme.

Between 30° and 40°C., where the rate of energy utilization reaches a minimum, the rate of water loss becomes appreciably higher; and above 40°C. it becomes excessive (Kendeigh, 1944). At high air temperatures a more rapid evaporation of water through the respiratory system is required to accelerate heat loss from the body. The greatly shortened survival at high air temperatures is due to inability to attain or maintain the requisite rate of water loss and death results from hyperthermia (Kendeigh, 1944).

RESISTANCE TO HUNGER IN OTHER SPECIES

Experiments on other species of birds (Table 2) were conducted in a manner similar to those with the English sparrow, except for the studies by Gerstell (1942) and Errington (1939). Gerstell placed his birds at −18°C. in a constant temperature chamber with no air movement and with the illumination varying between day and night as out-of-doors. In comparable experiments but with an air movement of 5.8 miles per hour, survival time was reduced almost 25 per cent. Other experiments by Gerstell and those by Errington were conducted under uncontrolled conditions and the temperatures here given are the approximate means of the fluctuations.

Nearly all of the birds in the experiments of Gerstell and of Errington, except the great horned owl and red-shouldered hawk, were of artificially propagated stock. Compared with a survival period of 340 hours reported for the ring-necked pheasant at −1°C. Gerstell found that of 25 wild trapped birds confined at comparable temperatures, 13 individuals were still alive and fully active after 840 hours without food. Because of these many variables the results obtained by those two workers and by ourselves are not strictly comparable, but the variations between species have at least a relative significance.

The data in general support the prin-

TABLE 2.—SURVIVAL TIME WITHOUT FOOD OF VARIOUS BIRDS AT COMPARABLE TEMPERATURES.

Species	Month or season	Number of records	Average temperature, °C.	Survival, hours	Initial weight, grams	Final weight, grams	Percentage weight lost	
							Total	Per hour
White-throated sparrow (*Zonotrichia albicollis*)	October	3	−17	16	26.6	21.7	*18.4*	*1.15*
White-crowned sparrow (*Zonotrichia leucophrys*)	October	4	−18	19	27.5	21.6	*21.5*	*1.13*
English sparrow (*Passer domesticus*)	Dec.–Mar.	13	−14	19	28.9	24.4	*15.6*	*0.82*
Tree sparrow (*Spizella arborea*)	March	3	−13	31	21.1	14.7	*30.3*	*0.98*
Slate-colored junco (*Junco hyemalis*)	Jan.–Apr.	12	−14	37	21.8	16.0	*26.6*	*0.72*
Bobwhite quail (*Colinus virginianus*)[b]	March	10	−18	60	167	127	*24.0*	*0.40*
Hungarian partridge (*Perdix perdix*)[b]	March	2	−18	168	347	209	*39.8*	*0.21*
Ruffed grouse (*Bonasa umbellus*)[b]	Feb.–Mar.	2	−18	185	615	422	*31.4*	*0.17*
Mallard (*Anas platyrhynchos*)[b]	Mar.–Apr.	8	−18	225	1,023	676	*33.9*	*0.15*
Red-shouldered hawk (*Buteo lineatus*)[b]	March	1	−18	260	858	513	*40.2*	*0.15*
Chukar partridge (*Alectoris graeca*)[b]	March	2	−18	270	627	354	*43.5*	*0.16*
Great horned owl (*Bubo virginianus*)[b]	Jan.–Feb.	6	−18	305	1,735	1,239	*28.6*	*0.09*
Wild turkey (*Meleagris gallopavo*)[b]	March	2	−18	324	4,869	3,303	*32.2*	*0.10*
English sparrow	Dec.–Mar.	11	− 1	23	29.2	24.4	*16.4*	*0.71*
White-throated sparrow	October	9	− 1	32	27.6	20.2	*26.8*	*0.84*
Tree sparrow	March	4	− 5	40	19.8	13.4	*32.5*	*0.81*
Slate-colored junco	Jan.–Apr.	20	− 3	51	21.8	14.9	*31.7*	*0.62*
Starling (*Sturnus vulgaris*)	Feb.–Mar.	7	− 1	64	86.5	61.4	*29.0*	*0.45*
Ring-necked pheasant (*Phasianus colchicus*)[a]	Jan.–Feb.	16	− 9	336	1,045	605	*42.1*	*0.13*
Ring-necked pheasant[b]	February	24	− 1±	340	1,167	735	*37.0*	*0.11*
Bobwhite quail[b]	March	8	+ 4±	92	165	112	*32.1*	*0.35*
Bobwhite quail[a]	Winter	17	4±	168	190	115	*39.5*	*0.24*
Ruffed grouse[b]	Feb.–Mar.	2	6±	180	567	388	*31.6*	*0.18*
Red-shouldered hawk[b]	March	1	6±	260	663	468	*29.4*	*0.11*
Mallard[b]	Mar.–Apr.	6	5±	276	1,083	716	*33.9*	*0.12*
Hungarian partridge[b]	Mar.–Apr.	2	2±	300	377	193	*48.8*	*0.16*
Great horned owl[b]	March	1	6±	310	1,693	1,221	*27.9*	*0.09*
Wild turkey[b]	March	2	2±	336	4,690	2,708	*42.3*	*0.13*
Chukar partridge[b]	March	2	6±	348	638	327	*48.7*	*0.14*
Wild turkey[b]	March	1	6±	576	3,568	1,752	*50.9*	*0.09*
Slate-colored junco	Jan.–Apr.	4	35	54	20.7	14.6	*29.5*	*0.55*
English sparrow	Dec.–Mar.	14	34	61	30.4	19.6	*35.5*	*0.58*
White-crowned sparrow	October	3	38	5	32.4	29.5	*9.0*	*1.80*
White-throated sparrow	October	20	37	7	27.8	24.2	*12.9*	*1.84*
Tree sparrow	March	4	38	7	20.5	17.9	*12.7*	*1.81*
Slate-colored junco	Jan.–Apr.	3	37	12	20.7	16.5	*20.3*	*1.69*
English sparrow	Dec.–Mar.	4	38	15	30.1	25.1	*16.6*	*1.11*

[a] Errington, 1939.
[b] Gerstell, 1942.

ciples worked out with the English sparrow. The longer survival periods in each range of temperature are correlated with increase in percentage of the initial weight lost at time of death, with decrease in the hourly rate at which this weight is lost, or with both.

The total weight loss and the hourly rate of loss may vary independently of the initial body weight and of each other. The tree sparrow and slate-colored junco live longer at low temperatures than the white-throated, white-crowned, and English sparrows, despite their being of lesser weight, because they tolerate a greater loss of

weight before death and because they lose weight more slowly. The junco appears to be slightly more resistant than the tree sparrow because it loses weight more slowly and not because it loses more weight. The great horned owl lives about ten times longer at very low temperatures than the tree sparrow, not because its weight loss is greater but because it loses weight only about one-tenth as fast. Differences between other species may be explained similarly. The mallard seems to have less resistance and the chukar partridge more resistance than would be expected from their respective weights.

Since the weight lost at all save very high temperatures is largely from fat, birds that tolerate a greater weight loss must have a corresponding greater fat storage. Species apparently vary in their ability to store fat and this needs to be studied in a quantitative manner at all seasons (McCabe, 1943). Greater deposits of fat beneath the skin also would serve as insulation to retain body heat and reduce the rate at which fat is lost. Large birds have a lower proportion of body surface to body mass which would reduce the rate of heat loss. The effectiveness of the feather covering in different species needs to be determined. From the data available on the number of feathers or weight of the plumage in different species (Kendeigh, 1934; Wetmore, 1936) it is not possible to demonstrate that over-wintering species have more feather insulation than those that migrate. The number of feathers tends to be relatively greater in small birds (Hutt and Ball, 1938). Ability to store fat in large quantities and to use it economically is affected by hormones, especially from the thyroid gland. Riddle, Smith, and Benedict (1932) demonstrated a difference in metabolic response between resident domestic pigeons and migrant mourning doves which they believed due to a difference in the way the thyroid glands responded to cold.

HUNGER RESISTANCE VS. MIGRATION, DISTRIBUTION, AND ABUNDANCE

In the northern states the midwinter nights are from 14 to 15 hours in duration. All birds except nocturnal species must be able to endure these periods without food. The curve of survival for the English sparrow drops below this critical point (Fig. 1) when the temperature falls below −18°C. Some less vigorous birds cannot tolerate 14.5 hours without food, even at temperatures of −7°C. Among birds confined in outdoor cages, dead individuals were found after most nights with such low temperatures, although the more hardy individuals survived; and at higher temperatures there was little mortality. Under free natural conditions, English sparrows seek out night roosting sites in dense thickets, vines, natural cavities, buildings, straw stacks, and similar locations where they obtain shelter from the cold and where they are able to conserve their body heat. The air temperature in these situations is doubtlessly raised above that outside by radiation from the birds themselves. In the northern states the species occasionally experiences outdoor temperatures down to −30°C. or lower; ability of the species to survive there depends on individuals finding these sheltered nooks. Nichols (1935) found, however, that considerable numbers of adults in a population disappeared during severe

winters. It is obvious that to survive at low temperatures small birds must feed every day, both to replenish the energy lost the preceding night and to build up a reserve for the night to come. Any difficulty in finding abundant food is critical.

The white-throated and white-crowned sparrows have a tolerance to cold and hunger about equal to that of the English sparrow. Hardy individuals of the former occasionally remain over winter, but normally these species migrate and winter in the southern states as they have not acquired the advantageous roosting behavior of the English sparrow. The slate-colored junco and tree sparrow normally spend the night in dense ground vegetation or in thickets that give them some protection, and their greater physiological tolerance permits them to endure greater exposures than the English sparrow. Many individuals stay over winter in the northern states but others migrate. It may be that with many species, migration is induced, not by total inability to survive northern winters under favorable circumstances, but by the greater strain so placed on the metabolic exchanges when they do so. By migrating into warmer winter climates energy requirements are less exacting, food is more easily obtained, and there is greater physiological comfort.

Among the larger species a single night is seldom critical for vigorous birds, but long periods when the food supply is covered with snow may reduce the population. A protective behavior pattern in the bobwhite is to huddle together in a characteristic circular formation. Gerstell (1942) demonstrated that when permitted to do thus the birds survived 50 per cent longer than when confined in individual cages. Ruffed grouse dive into snow banks to spend the night, thereby escaping the wind and cold of exposed positions. Mallards will remain over winter if they have access to sufficient waste corn in upland fields and to open water. Starlings that find refuse dumps near a city also overwinter in the north. The red-shouldered hawk usually moves southward and avoids periods when snow renders the finding of prey difficult. The other species are permanently resident.

Although the experiments summarized in Table 2 were not designed for correlation of resistance to heat with northward migration in spring, they nevertheless show that the white-crowned, white-throated, and tree sparrows have but little resistance to high temperatures. All three species migrate far north into Canada to nest, although the white-throated sparrow occurs to some extent in the higher and cooler elevations of mountains to the south. The slate-colored junco nests farther south than the other three sparrows and likewise has a greater tolerance to heat. The English sparrow shows the greatest resistance and nests as far south as the Gulf states. Behavior adjustments of birds to hot weather involves decreased activity and feeding but increased water consumption. The birds perch with extended wings, and pant vigorously through opened bills, and seek shade. Along with these disturbances in normal behavior goes a decrease in reproductive vigor (Kendeigh, 1941).

SUMMARY

1. Survival time of English sparrows without food during the winter is longest, 67.5 hours, at 29°C. As air temperatures drop to 10°C. survival time decreases two hours per degree, but from +10°C. to −40°C., the drop averages only one-half hour per degree. With rise in air temperature from 29° to 46°C., survival time decreases at the rate of four hours per degree.

2. At temperatures from −19° to +35°C., birds of greater weight live longer without food than individuals of lesser weight, because the extra weight is principally fat. The longer survival time of males, as compared with females, is due to their greater weight.

3. The largest loss of weight before death from starvation comes at 34°C., averaging 36 per cent of the initial weight. At −32° and +43°C., the loss is only 5 and 6 per cent, respectively. The hourly rate of weight loss varies inversely with the total weight loss, save that the minimum rate comes at 29°C. rather than 34°C.

4. There is maximum utilization of fat in starvation only from 21° to 35°C. so that only at these temperatures is death dependent upon exhaustion of the energy reserves. Death at lower temperatures occurs from inability to maintain for long the greatly increased rate of heat production. At high temperatures death is from hyperthermia resulting from inability to maintain a sufficiently increased rate of water evaporation.

5. Differences between species and between the individuals of one species in survival time without food are due to differences in the relative amount of utilizable fat stored in their bodies and in the rate at which it is metabolized.

6. Adjustments in behavior may compensate in part for deficiencies in physiological vigor and modify the controlling role of temperature and of hunger on distribution, migration, and abundance.

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SEASONAL FUR PRIMENESS OF THE COYOTE IN THE WESTERN UNITED STATES

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The coyote (*Canis latrans*) is known in the fur trade as "wolf" or "prairie wolf" but is not, as the latter name implies, confined to the plains region. In recent years it has spread to the eastern United States and north through Canada into Alaska. In the West, where its numbers still remain the greatest, it occurs from low deserts to high mountains.

Coyotes, because of their abundance, are probably the most destructive of western American carnivores. Their ecological adaptability to changes brought about by agricultural development have led to serious conflicts with the livestock industry. Annual losses among range sheep have been estimated to be from 1 to 3 per cent of the herds (Bailey, 1931) and some reports indicate losses of 12 to 14 per cent. A recent comprehensive report on the food of the coyote (Sperry, 1941) showed that domestic livestock amounted to 13.5 per cent of the diet, but that rabbits (33%) and rodents (18%) constituted the greater portion. In the control work of the U. S. Fish and Wildlife Service and cooperators against predators in national forests and on western stock ranges from 1915 to 1925, 186,172 coyote skins were obtained and sold (Adams, 1926). In the fiscal year 1941, 110,495 coyotes were taken in cooperative control financed by federal, state, and county agencies, and by livestock and agricultural association funds (Gabrielson, 1941). Many of the latter skins, however, were taken during the summer and not retained.

Fur of the coyote is valuable and is sought by private trappers and predatory animal hunters alike during the season when prime. The skins are used mainly for garment trimming and for scarfs. Those from the southwestern sections are poorest in quality, while pelts from the northern Rocky Mountain region are better furred, more durable, and of greater value.

An incomplete survey of the 1941 fur catch indicates that more than 100,000 coyotes were trapped for fur in addition to those taken by predator control workers. During the same year more than 125,000 coyote pelts were offered for sale by three leading fur auction companies. The average value per pelt varied from $6.00 to $8.00 and select skins from the northern Rocky Mountains brought up to $18.50 in one sale. The meager information available indicates that the total annual value of raw coyote pelts produced in the United States approximates $1,000,000.

This study deals with 5,621 pelts taken by Federal hunters in the eleven Western States from August 1940 to April 1941. To compare the length of season for prime fur in the several climatic zones within this large area, the data are listed by three geographic regions: Southwestern, Northwestern, and Rocky Mountain. Fur gradings of

all pelts were obtained from the Seattle Fur Exchange, using its numerical system of grading.

Of 5,521 animals which were sexed, males predominated in the Southwestern and Rocky Mountain regions, and females were more numerous in the Northwestern sample (Table 1). The male:female ratio for the entire area was 51+:49−(102:100).

Since the hair of the coyote follows a climatic or seasonal cycle in growth and shedding, pelts are graded and separated into seasonal classes. The prime fur season in an area covering several states may extend from October to February or March, depending upon altitude, climate, and geography. Pelts of superior quality taken at that time are known as "prime" or "winter."

With the approach of warm spring weather, the fur begins to fall out, and pelts taken late in spring are noticeably lacking in underfur, which begins to shed first. The coarse textured guard hairs then become more prominent and, being no longer held erect by dense surrounding underfur, tend to lie close to the skin. This type of pelt is termed "flat" or "springy."

Worn spots may develop on the sides or rump where the guard hairs, through abrasion, break off near their tips. Such skins are classified as "rubbed" or "badly rubbed." Another detrimental feature also may be observed in the guard hairs of late caught pelts. These may become turned or bent over at the tips, giving the whole pelt a dull, lifeless appearance known as a "singed."

Summer pelts are valueless from the furrier's viewpoint and are not found on the fur market. Coyotes, of course, are trapped during the summer to control their depredations on livestock and game, but the pelts are not saved, being faded in color, and the fur appears much shorter because of the scanty covering of guard hairs.

According to Bachrach (1930), early autumn pelts are preferable to those of late spring because they already possess a fairly dense underfur, although the guard hairs may not be fully grown out. Pelts taken prior to the fully prime period are termed "early fall," "fall," or "late fall" by certain fur dealers.

In addition to the seasonal terms used to described pelt quality, there is also a numerical system, graphically described by Bachrach (1930), which more or less correlates with the former. The numerical system is employed widely through the fur trade and is the basis

TABLE 1.—SEX RATIOS IN COYOTES BY GEOGRAPHIC REGIONS, WESTERN UNITED STATES, 1940–41.

Region	*Numbers*		*Sex ratio*
	Male	*Female*	*Male:Female*
Southwestern States (Ariz., Calif., New Mex., Nev.)	1,629	1,431	53:47 (113:100)
Northwestern States (Ore., Wash., Idaho)	438	513	46:54 (85:100)
Rocky Mountain States (Colo., Mont., Wyo., Utah)	774	736	51:49 (102:100)
Totals	2,841	2,680	106:100

upon which data in the accompanying tables were recorded. For example, a fully prime winter pelt is a "One." An early caught (autumn) or late caught (spring) coyote, slightly inferior in quality, may be classed as a "Two." "Low Two" and "Three" skins may be very springy or early caught, and still lower grades from the unprime season may be designated as "Threes," "Fours," or "Young Immatures." In Threes and Fours there is often much material to be cut away by the furrier because of tinged, rubbed, or partially shed areas which are worthless. Pelts damaged by shot holes, cuts, tears, or poor handling in skinning or drying, and those damaged by insects (usually larvae of the clothes moth or dermestid beetle) are always placed in the lower grades.

One characteristic of an animal pelt which determines its value as fur is primeness. This has been investigated by Gunn (1932b) who showed that primeness is associated with depigmentation of the hair roots and is entirely independent of skin thickness or apparent skin pigmentation. In a paper on muskrat pelts, Gunn (1932a) stated that the pigment is continuous from the root outward into the hair shaft in hairs from an umprime pelt. Unprimeness may not be due to apparent pigmentation of the leather itself, known popularly as a "blue" pelt, but rather to the massed effect of the pigmented hair roots. Conversely, the condition known as primeness results from depigmentation or blanching of the hair roots. Disappearance of the pigment from the root of the hair does not terminate at the skin level, but continues a short distance out into the hair shaft. This process usually is hastened by the advent of cold weather in the autumn, but is not dependent entirely upon climatic conditions. In mild winters pelts become prime, although usually 10 to 15 days later. As the pigment leaves the hair bulb, the slate color or blue appearance of the leather gradually disappears until the latter is completely devoid of pigment. Then in prime condition, the leather is cream colored to nearly white and soft and pliable. Growth of hair fibers is completed first on the ventral and lateral surfaces, and "blue" leather, indicating unprimeness, persists longer on the dorsal surfaces, particularly on the back of the neck just anterior to the base of the tail and in small scattered patches along the mid-dorsal line.

Thus the terms "prime" and "unprime," when applied to fur skins, may indicate the condition of either the leather or the fur fibers, or both. A prime skin is fully furred, both the guard hairs and underfur having attained the maximum in natural development as to growth and quantity. In coyote pelts, decision as to quality also rests somewhat on the density of the underfur fibers which tend to hold the guard hairs upright and give the entire pelt a desirable bushy or fluffy appearance. Popular conceptions of the meaning of the word primeness or of the physiological processes involved often are vague and erroneous, indicating the need for further research and clarification of the subject.

Most Western States have no closed trapping season on predators such as coyotes, but their legal seasons on other fur animals usually start November 1 or 15 and continue until March. If we con-

TABLE 2.—GRADING OF COYOTE PELTS, WESTERN UNITED STATES, 1940–41.

Month trapped	Pelt grades						Totals
	One and Two		Three and Four		Low, poor, and damaged		
	%	No.	%	No.	%	No.	
SOUTHWESTERN STATES (Arizona, California, New Mexico, Nevada)							
September	67	80	—	—	33	39	119
October	88	565	10	64	2	13	642
November	88	457	8	40	4	24	521
December	72	355	19	93	9	46	494
January	65	557	30	258	5	46	861
February	53	222	20	84	27	115	421
March	58	56	17	16	25	24	96
Average percentages	73		18		9		
Totals		2,292		555		307	3,154
NORTHWESTERN STATES (Oregon, Washington, Idaho)							
August	—	—	100	3	—	—	3
September	56	49	42	37	2	2	88
October	90	262	7	21	3	8	291
November	84	184	14	30	2	6	220
December	88	137	11	17	1	1	155
January	88	94	12	13	—	—	107
February	81	29	19	7	—	—	36
March	81	44	—	—	19	10	54
Average percentages	84		13		3		
Totals		799		128		27	954
ROCKY MOUNTAIN STATES (Colorado, Montana, Wyoming, Utah)							
September	55	12	45	10	—	—	22
October	85	226	14	40	1−	1	267
November	88	305	12	43	—	—	348
December	90	303	10	33	—	—	336
January	83	188	17	39	—	—	227
February	87	188	13	29	—	—	217
March	88	83	12	11	—	—	94
April	100	2	—	—	—	—	2
Average percentages	86+		13+		1−		
Totals		1,307		205		1	1,513

sider Number One and Two pelt grades as good serviceable skins, it is evident (Table 2) that even in October 85 per cent or more of the 1,200 skins from all three sections were of this kind and that it would be economically feasible for a private trapper to operate during that month.

Pelts from coyotes trapped in September were unsatisfactory from all regions. Observations on captive coyotes by Whiteman (1940) indicated that

spring shedding may not be completed until July and new growth of guard hairs and underfur is evident during August and September; by October, therefore, the animals possess the long dense covering which characterizes the winter pelt. Except in the Southwestern region (Table 2), the pelt quality seems to remain high throughout the winter, until the end of March. Coyotes in the Pacific Northwest and the Rocky Mountain States show a similar seasonal trend. The pelt quality of animals from the Southwest, as interpreted from data in this paper, seems to decrease rapidly after December, indicating a shorter prime fur season there. If the data are interpreted on a seasonal basis, pelts from the Rocky Mountain region were first in quality, 86 per cent of the catch grading Number One and Two; those from the Northwestern region were second (84%), and those of the Southwestern States third (73%). Conversely, the last region produced the greatest number of low, poor, and damaged skins, 9 per cent of its pelts being so designated. It has long been realized that there is a tremendous economic waste in the improper preparation or storage of raw pelts before they are shipped to market. This tendency would be more noticeable in the Southwestern region where climatic conditions are less severe. Cold weather retards both the decay and the damage of furs by insects.

Coyote fur is a valued article of commerce in our fur industry and because of the adaptability of the coyote to agricultural development will continue to be of much importance in the American wild fur crop.

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SEX RATIO AND WEIGHTS OF MUSKRATS FROM THE MONTEZUMA NATIONAL WILDLIFE REFUGE[1]

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After several years of development and water impoundment, trapping was initiated on the Montezuma National Wildlife Refuge at Seneca Falls, New York by the U. S. Fish and Wildlife Service in 1943. A total of 1,455 muskrats (*Ondatra z. zibethicus*) was taken from January 12 to March 20 of that year under conditions of extreme freeze-up. Of these, 635 were sexed and showed a ratio of 339 males (53.3%) to 296 females. Weights were obtained by Manager Merton Radway on 213 males and 161 females from March 16 to 20; they averaged 3.4 pounds and 3.1 pounds, respectively. The number of extra large skins and the top prices obtained produced favorable comment at sales in New York, these being the largest muskrat skins received by the auction during the 1943 season. The writer visited the Montezuma Refuge from January 25 to 30 and March 14 to 20, 1944, during the trapping season, to seek the reason for the large size and heavy weight of the muskrats there.

Description of Area

In the triangle of Cayuga, Seneca Falls and Wayne counties, there is a low basin of black muck land, the Montezuma Marshes, consisting of about 10,000 acres of productive muskrat marsh; the remainder has been drained and now is a highly fertile area for truck farming.

The Refuge, of 5,802 acres, lies at the north end of Cayuga Lake, bounded on the north by the Clyde River and on the east by the Barge Canal. Through dike construction, the flooded area comprises an upper or storage pool of about 700 acres and a lower or main pool of about 1,500 acres. The storage pool was completely impounded in December 1942, and muskrats were trapped on about 300 acres in 1943. Since this pool serves to insure adequate water for the lower diked area, the water conditions are not conducive to a high muskrat population. Dikes on the lower pool were completed in October 1941, when impoundment began, but it was not completely flooded until late March 1942. Over much of this area the water has been maintained at an appropriate level to improve the fine growth of cattail and burreed, favorite food plants of the local muskrats; this condition greatly increased the possibilities of utilization of the growth by muskrats. In 1944 about 500 acres contained sufficient muskrats to warrant trapping.

During nearly every spring season, almost the entire marsh is flooded by freshets from the Clyde and Seneca rivers, when water backs up to the spillways and must be equalized, but this condition lasts only a few days; its effect on the muskrat population is problematical.

Owners and trappers of adjoining

[1] Refuge Manager, Merton Radway, and Acting Refuge Manager, J. Kenneth Magargel, cooperated in securing the data, and Leonard M. Llewellyn assisted in the computation and analysis of the records.

marshes reported the winter of 1944 was one of the mildest and most favorable for trapping in over thirty years. The sex and weights of the 3,919 muskrats taken on the refuge during that season were obtained, through the continued cooperation of the manager and his staff (Table 1).

SEX RATIO

The catch was not segregated into kits and adults. There were 2,152 (55%) males and 1,767 females, a sex ratio of 122:100. The preponderance of males was highly significant; and was maintained throughout the trapping operations. This tends to confirm findings (Dozier, 1944) for *Ondatra z. macrodon* on the Blackwater Refuge in Maryland which are in disagreement with the common belief of trappers that more females than males are taken in the last few weeks of the trapping season.

WEIGHTS

Weights were taken to the nearest quarter of a pound on a Columbia household spring scale soon after the muskrats were brought from the traplines; the animals, therefore, varied in degree of drying, but this was believed to have made no significant difference in the results.

There were remarkably few small muskrats. The 2,152 males ranged from 1 pound 8 ounces (24 oz., 680 g.) to 5 pounds 4 ounces (84 oz., 2,381 g.), the mean being 3 pounds 10 ounces (58 oz., 1,644 g.) with a standard deviation of 8.84 ± 0.14 oz. (250.6 ± 4.0 g.); the 4 pound (64 oz., 1,814 g.) class contained 429, the largest number of individuals. Among the 1,767 females, the extremes were 1 pound 4 ounces (20 oz., 567 g.) and 5 pounds (80 oz., 2,268 g.), and the mean weight was 3 pounds 5 ounces (53 oz., 1,503 g.), the standard deviation being 8.21 ± 0.18 oz. (232.8 ± 5.6 g.); the 3 pound (48 oz., 1,361 g.) class was the largest with 213 individuals. The mean for all animals was 3 pounds 8 ounces (56 oz., 1,588 g.), showing a standard deviation of 8.80 ± 0.14 oz. (249.5 ± 4.0 g.). There was a progressive increase in the weights of males throughout the trapping season. When growth rates are worked out for the muskrats of this area, the data on numbers of individuals in the several weight groups may be helpful in planning best trapping management of the population.

These figures are in marked contrast to weights reported for the Maryland muskrat (Dozier, 1944) where the average for adult males was 2.3 pounds and for females, 2.2 pounds. The slightly longer season for reproduction in Maryland may result in later litters of young which affect the general weight average at trapping time. During 1944, however, there was little evidence of late breeding on the Blackwater Refuge. In three years at that refuge, only three of the muskrats weighed 4 pounds, while at the Montezuma Refuge muskrats of this weight were common and constituted the male group having the greatest number. Of 50 trapped on March 7 there were 27 weighing 4 pounds or over; two of them weighed 5 pounds and one 5 pounds 3 ounces. The largest, a brown male trapped January 29, weighed 5 pounds 4 ounces; its measurements, in inches, were: body, $14\frac{1}{2}$; tail, $10\frac{3}{4}$; right hind foot, $3\ \frac{7}{16}$; greatest width of tail, $1\frac{5}{8}$.

Schoonmaker (1929) gave the average of 11 muskrats from New York as

TABLE 1.—THE MUSKRAT CATCH ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE, NEW YORK, 1944

Period		Catch		Percentage of males	Males per 100 females	Average weights (pounds)		
		Males	Females			Males	Females	Combined
January	1–15	381	375	50	102	3.4	3.3	3.3
	16–31	572	487	54	117	3.4	3.2	3.3
February	1–15	420	279	60	151	3.5	3.3	3.4
	16–29	322	213	60	151	3.8	3.4	3.6
March	1–20	457	413	52	111	3.9	3.4	3.7
Totals		2,152	1,767	55	122	3.6	3.3	3.5

only 2.34 pounds, with one female weighing 3.5 pounds. Of local variations in the size of New York muskrats, Johnson (1925) states that "Among local trappers and handlers of raw furs the view is sometimes met with that the muskrats of one section of the State are distinguished from those of another region by rather positive differences in size." A summary of known weight records from Vermont, Pennsylvania, Delaware, Wisconsin, and Iowa for this race are given by Dozier and Allen (1942). These all show average weights distinctly smaller than those from the Montezuma Refuge.

The Montezuma Refuge muskrats outweigh the Maryland race by an average of one pound and are distinctly larger in measurements (Table 2). The stockier, heavy-set appearance, very wide tail(to $1\frac{3}{16}$ inches), and more docile disposition of the Montezuma muskrats (*zibethicus*) were in marked contrast to the longer, narrower-tailed, and more vicious excitable animals from the Blackwater Refuge (*macrodon*).

Mr. Gene Lay, former owner of part of the present Government holdings, has stated that over fifty years ago, when he was a boy, animals from the Montezuma marsh were always the largest and the skins were considered tops in size, quality, and market price.

TABLE 2.—MEASUREMENTS AND WEIGHTS OF SOME MUSKRATS (ONDATRA Z. ZIBETHICUS) TRAPPED ON THE MONTEZUMA NATIONAL WILDLIFE REFUGE, 1944.

Date	Sex	Measurements, mm.			Weight, grams	Pelt weight, grams		Amount of fat, grams			Total fat, grams
		Body	Tail	Hind foot		Unfleshed	Fleshed	Pelt	Body	Viscera	
Jan. 25	F	342.9	254.0	79.4	1,701.0	368.5	255.1	113.4			
25	F	349.3	228.6	82.6	1,502.5	368.5	255.1	113.4			
25	F	336.6	241.3	77.8	1,417.5	311.8	226.8	85.0			
25	F	336.6	231.8	84.1	1,332.4	283.5	170.1	56.7			
25	M	355.6	266.7	87.3	1,927.8	481.9	340.2	141.7			
25	M				1,615.9	368.5	283.5	85.0			
25	M	336.6	273.1	87.3	1,899.4	481.9	340.2	141.7			
25	M				1,474.2	311.8	255.1	56.7			
25	F	362.0	254.0	84.1	1,474.2	396.9	311.8	85.0			
25	F				1,672.6	368.5	311.8	56.7			
25	F				1,842.7	368.5	311.8	56.7			
25	M	368.3	266.7	84.1	1,502.5	283.5	226.8	56.7			
27	F	381.0	285.8	85.7	2,041.2	368.5	311.8	56.7			
27	F	317.5	231.8	82.6	1,701.0	340.2	283.5	56.7			
28	M	317.5	254.0	85.7	1,927.8	396.9	368.5	28.3			
28	M	330.2	266.7	87.3	1,927.8	396.9	368.5	28.3		28.3	
28	M	342.9	298.5	88.9	2,041.2	425.2	368.5	56.7	42.5	28.3	127.6
28	M	304.8	247.7	85.7	1,701.0	311.8	283.5	28.3	70.9	28.3	127.6
28	M	304.8	254.0	85.7	1,672.6	311.8	269.3	42.5	28.3	7.1	77.0
28	M	304.8	241.3	79.4	992.2	283.5	226.8	56.7	21.3	14.2	92.1
28	M(Kit)	254.0	203.2	74.6	822.1	113.4	—	—	—	—	—
29	M	368.3	273.7	87.3	2,381.4	453.6	—	—	—	—	—
29	F	381.0	266.7	87.3	1,927.8	453.6	396.9	56.7	35.4	28.3	120.5
Mar. 18	M	381.0	260.4	82.6	2,182.9	368.5	396.9	56.7	113.4	56.7	226.8
18	F	—	—	—	1,701.0	—	255.1	113.4			

This was vouched for by Foster Helmer, present Government trapper, who formerly leased marsh from Mr. Lay and who has trapped there for over 30 years. Both state that as long as they can remember there have always been a few black muskrats present although they are rare.

There was much fat on the Montezuma muskrats, while those from Maryland had scarcely any. The skins of the former were thicker and tougher and the fur was denser and apparently longer. Pelts of some of the larger animals weighed as much as 17 ounces before fleshing, and 14 ounces after the fat had been removed. The amount of fat was determined by weighing the fresh skin before and after fleshing, by cutting off most of that which remained on the body after skinning, and by removing the four large pieces of visceral fat (Pl. 10, A). On some the total fat weighed as much as 8 ounces. Correct comparisons between weights of muskrats from different sections cannot be made accurately unless the amount of fat is considered.

The muskrats from the upper pool averaged at least one-third less in weight than those from the lower pool and had little fat (Pl. 11, A). Apparently this can be attributed to the water level in the upper pool being too high for optimum muskrat requirements and proper food conditions. There are also several sulphur springs on this pool that give off a continuous nauseous stench and may exert a deleterious effect on the muskrats. Adjacent to the swampy woods, predation is serious, with raccoons, minks and foxes greatly on the increase.

There were few small muskrats (weighing 2 pounds 4 ounces or less), and these appeared to be young born in the autumn previous to trapping. There was considerable variation in the sex ratio in the several weight and age groups. This may be attributed to possible differences in the actual sex ratio, selective trapping, non-productive animals, effects of predation, and to differential survival ability between the sexes as to losses during pregnancy and lactation, and by disease.

FOOD PLANTS

The refuge staff and trappers were unanimous in their opinion that the available food plants used by muskrats on the Montezuma Refuge, in order of preference, are (1) narrow-leaved cattail (*Typha angustifolia* var. *elongata*) known by the industrial name of "blue-flag" or "cooper's flag," and the broad-leaved cattail (*T. latifolia*), known locally as "soft flag," both being used for tight-work oak barrel making; (2) burreed (*Sparganium eurycarpum*); (3) three-square bulrush (*Scirpus americanus*), quite limited in distribution; (4) hard-stem bulrush (*Scirpus acutus*); (5) river bulrush (*Scirpus fluviatilis*); and (6) sweet flag (*Acorus calamus*). The two most important are the blue flag and the burreed.

Stearns and Goodwin (1941) in their analytical study of 10 representative cover plants of a muskrat marsh in Delaware state "it is apparent that the percentages of crude protein and nitrogen-free extract for the roots are invariably higher than those for the tops." They found 7.61 per cent crude protein in dried and finely-ground roots and rhizomes of *Typha angustifolia* on "still-water" or embanked marshes and 2.45 per cent in the tops (average 5.03%). For roots and tops of *Scirpus olneyi*

on tidewater areas the respective figures were 6.47, and 2.01 (average 4.24%).

Freudenthal (1922), in discussing the practical value of cattail as feed for hogs in New Mexico, noted the large amount of food material in the starchy central core of the rhizome; he gave the percentage composition of cattail flour as 7.75 protein, 2.84 ash, 0.65 fat, 81.41 carbohydrates, and 7.35 moisture.

The submerged portions of the dominant food plants at the Montezuma Refuge were examined. Clumps of narrow-leaved cattail cut from beneath 6 to 7 inches of ice contained numerous short, growing points or young shoots, 4 to 5 inches in length (Pl. 11, B). These shoots start in late autumn and then remain more or less stationary beneath the ice until spring. Together with the rootstocks, they constitute a substantial portion of the muskrat diet and undoubtedly are a valuable source of essential nutrients. The plant remains on feeding platforms of most of the shelters examined showed that muskrats are particularly fond of these tender, partly green shoots.

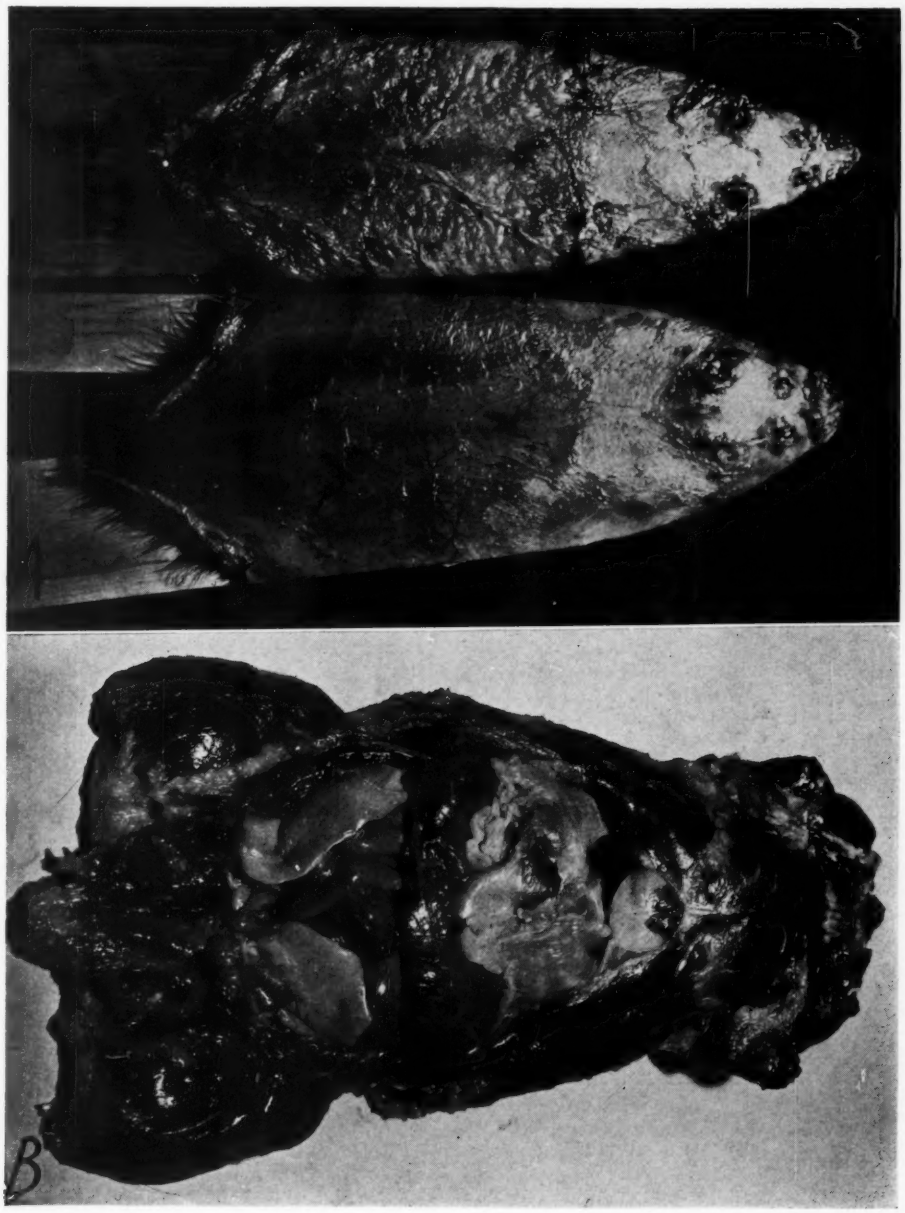
There was a distinct increase in the weight of male muskrats as the trapping season progressed (Table 1). The fine source of green winter food and the abundance of carbohydrates in this period is in marked contrast to the winter diet of the Maryland muskrat which is mainly of rootstocks of the three-square (*Scirpus olneyi*). This dietary difference seems to be a logical explanation for the larger size and fatter condition of muskrats on the Montezuma Refuge. The actual protein content in rootstocks of *Typha angustifolia* and *Scirpus olneyi* is not particularly high in comparison with many other vegetable foods and most animal foods. Also the protein content of the *Typha* rootstocks (7.61%) is not much larger than in those of *S. olneyi* (6.47%) as found by Stearns and Goodwin. Lacking more complete data on the composition of *Scirpus olneyi*, it seems likely that the lower food value of its rootstocks may be due to a relatively high percentage of indigestible crude fiber.

Johnson (1925) mentions that some trappers believe the differences in the size of muskrats probably are associated with the different character of the food material in various localities; that "the most important food of the muskrat, quantitatively at any rate, in the great marshes and swamps of western New York, is the cattail flag, both species." He points out further that the largest muskrats occur in the great central section but within that area there is one locality of small muskrats, in the Cazenovia region, where no important marshes or swamps occur.

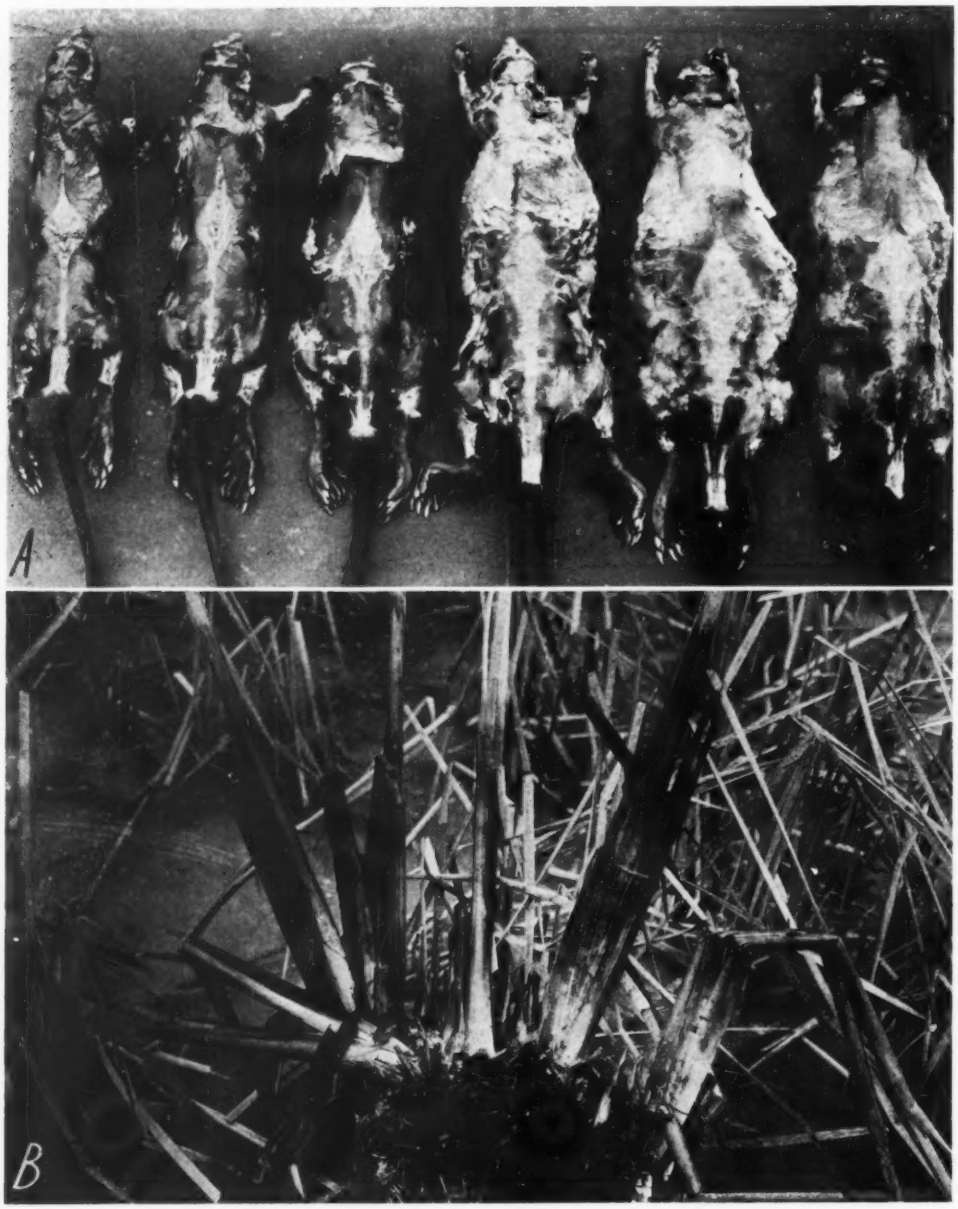
SUMMARY

1. Approximately 800 acres of marsh on the Montezuma National Wildlife Refuge in New York were trapped from January 1 to March 20, 1944, by three men and yielded 3,919 muskrats; 2,152 (55%) were males and 1,767 were females, a sex ratio of 122:100. This preponderance of males was maintained throughout the trapping operations and according to Fisher's "Z" test is highly significant (odds of 99:1).

2. Males were heavier than females, averaging 3.6 pounds (1,644 grams) and 3.3 pounds (1,503 grams), respectively. Statistically, this difference also is highly significant. The combined average weight was 3.5 pounds (1,588 grams), the highest yet noted. The



A. Muskrat pelt before removal of fat, contrasted with one after fleshing. *B*. Muskrat carcass opened to show the large amount of visceral fat, January 29, 1944. Montezuma National Wildlife Refuge, New York.



A. Muskrat carcasses from Montezuma Refuge, Seneca Falls, N. Y., showing at left the small size and lack of fat of those from the Storage Pool marsh, and at the right the large size and fatty condition of those from the Main Pool marsh; March 16, 1944. *B*. Clump of narrow-leaved cattail (*Typha angustifolia*) cut out from beneath ice of frozen marsh, showing the green winter shoots; March 15, 1944.

smallest muskrat caught weighed 1 pound 4 ounches. Arranged by 4-ounce weight groups, the 4-pound group contained the largest number of males.

3. The relatively huge weights of Montezuma muskrats are in marked contrast to those from the Blackwater Refuge, Maryland, which average 1.3 pounds less. This great difference can be partly accounted for by the amount of fat on the former as a result of better food and water conditions. In some of the larger muskrats about 8 ounces of fat was removed from the pelt, body, and viscera. This depends on the amount and quality of food present rather than to the more northern location. Accurate comparisons between weights of muskrats from different sections of the country cannot be made unless the amount of fat is considered.

4. Practically all muskrats trapped on the upper pool averaged at least a third less in weight and measurements than those from the lower pool and almost completely without fat. Water levels in the upper pool usually were too high for optimum muskrat requirements, especially for growth of proper food.

5. Examination of numerous feeding shelters showed that the favorite muskrat food on the Refuge in winter was the tender, partly green, growing shoots of cattail and the main roots of both cattail and burreed. These young shoots start in late autumn but remain 4 to 5 inches in length, beneath the ice, until spring. Undoubtedly they are a valuable source of essential nutrients.

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WHITE-TAILED DEER IN THE GREAT PLAINS REGION

Faxon W. Cook

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The encroachment of organized communities on the areas once occupied by large numbers of big game—buffalo, elk, deer, and antelope—that ranged the Great Plains has been the natural consequence of this country's development. Not even the most ardent conservationist believes that our objective should be the reestablishment of these animals in their original numbers, as the space and subsistence requirements of the citizenry come first. But it is also the right and privilege of our people to save for them and their descendants such wildlife populations as can be fitted into the present scheme of living. Americans are becoming more and more conscious that the wildlife be-

longs to all of them, and that these animals properly maintained are theirs to enjoy. Development of the concept that wildlife is the property of all Americans has been a slow process. The great abundance of wildlife was also its greatest weakness, and unthinking or greedy men levied on it to where some species ceased to exist except in private collections or zoological gardens, and many others were greatly depleted.

The white-tailed deer (*Odocoileus virginianus*) offers a good illustration of the reactions of a big game animal to human contact. By 1890 the species was nearly exterminated throughout much of its range in the eastern United States. Several North Atlantic and North Central states, becoming alarmed at its predicament and backed by an aroused public sentiment, have been able to restore deer through the establishment of refuges, by restocking programs, and by more stringent hunting regulations. On the Great Plains, the white-tail was fairly common in the woodland fringes along water courses but never as abundant as on other portions of its range, and became greatly restricted by advancing settlement. Use of the land for agriculture combined with brush and timber clearing operations destroyed much of the habitat on which it was dependent. The effect of land settlement and of uncontrolled hunting was to reduce the animals to small and widely scattered groups that maintained themselves with difficulty. Winter habitat became greatly restricted, although there was ample food available in the spring and summer. The deer ranged widely in summer, but with the approach of winter concentrated in the limited tree and brush growths along streams. Second only to winter habitat, hunting has been the most critical factor affecting the white-tailed deer in the Great Plains region. The importance of protection is well illustrated by the continued increase of deer herds on several national wildlife refuges in the Northern Great Plains region which have the added advantages of improved food and cover. The response of the animals to these more favorable conditions has been most notable in the Dakotas.

The refuges in North Dakota are quite alike in that most of them are along rivers and are characterized by low-lying hills that grade unevenly to the water's edge, thus providing small valleys or coulees in which there are the browse species common to the prairies—willow, poplar, ash, hackberry, chokecherry, buckbrush, dogwood and thornapple. When the refuge properties were acquired they had been subjected to over-grazing by domestic livestock and had suffered prolonged drought; consequently, the habitat suitable for deer was both limited and generally in very poor condition. Land management practices then started included the planting of cultivated crops to be left in the fields for migrating waterfowl. These food reserves proved equally beneficial to other wildlife including deer which have made considerable use of the wheat, millet, barley, and corn crops grown annually on those areas. Rank growths of wild sweet clover and ragweed following reversion of many fields provide an abundance of escape over. Subsequent timber management has helped to maintain the groves in healthy condition and has contributed to the supply of browse.

This has included the planting of indigenous species in locations promising successful establishment, the annual removal of dead and down timber in the groves, and light cutting of mature trees.

When the U. S. Fish and Wildlife Service acquired the Arrowwood National Wildlife Refuge in Stutsman and Foster counties, North Dakota, deer were rare (Table 1). This refuge extended some 18 miles along the James River embraces about 10,000 acres of grasslands, crop lands, and limited acreages of brush and timber. The improvements for wildlife involved the planting of food shrubs and trees native to the region together with the planting of tillable uplands to wheat, corn, and other crops for the use of wildlife in winter and early spring when natural food supplies usually are at a minimum. Today the Arrowwood Refuge is an important wintering ground for white-tailed deer from a large adjacent area. Their numbers have increased from an occasional animal to approximately 70 revealed in an aerial census during January 1944.

TABLE 1.—INCREASE OF WHITE-TAILED DEER ON SOME NATIONAL WILDLIFE REFUGES IN THE GREAT PLAINS ESTABLISHED IN 1935.

Refuge	Acres	Autumn population						
		1937	1938	1939	1940	1941	1942	1943
Arrowood	16,079	[a]	[a]	[a]	10	26	36	55
Des Lacs	18,676	30	35	35	[b]	60	140	175
Lostwood	26,308	[a]	[a]	[b]	9	9	17[c]	90
Lower Souris	58,455	[b]	600	790	1,085	1,200	835	1,085
Sand Lake	21,212	[a]	[a]	10	15	40	120	120
Upper Souris	32,168	10	[b]	45	115	425	445	525
Waubay	4,600	[a]	5	[b]	16	35	35	90

[a] Occasional.
[b] No count.
[c] Count of 28, winter, 1942–43.

The Des Lacs National Wildlife Refuge, Burke and Ward counties, North Dakota, has shown much the same development in respect to deer. The animals frequent the brush and timber-covered coulees that lead down to the lake shores, and one of the largest, Tasker's Coulee, contains a spring that is a favorite watering place as attested by the many well-beaten paths converging from all sides. From the coulees the deer range outward to feed in the surrounding countryside and as many as 48 in a single group were seen in 1944 on lands adjoining the refuge. There was also extensive use of corn fields on the refuge as at Arrowwood Refuge.

The Lostwood National Wildlife Refuge, Burke and Mountrail counties, North Dakota, is only about 15 miles southwest of the Des Lacs Refuge but differs greatly from the latter ecologically. It has numerous lakes, sloughs and potholes resulting from glaciation. Low-lying hills covered with grass and scattered clumps of trees and shrubs surround the lakes, and many sloughs are occupied by dense stands of bulrush and smartweed. Not until 1941 was more than an occasional deer seen, but in that year nine were counted. The

following winter (1941–42) the first definite proof of wintering use of the area was obtained, and increasing numbers have been noted each winter since.

The impoundment of water on the Souris River just before it crosses the International Boundary into Canada has restored much of the original marsh that was a veritable wildlife Eden until it succumbed to commercial exploitation. The Lower Souris National Wildlife Refuge, Bottineau and McHenry counties, North Dakota, offers sanctuary to all forms of wildlife and the white-tailed deer has taken advantage of the protection and the bountiful food supply. The southern third of the refuge, about 23,000 acres of heavily timbered river bottom, brushy sandhills and wooded coulees, affords excellent summer and winter range. At the time the refuge was established in 1935 some 100 animals were using the draws along the river and by November 1938 approximately 600 had been attracted to the area. Substantial increases the following two years resulted in a high population of between 1,200 and 1,500 animals on and in the immediate vicinity of the refuge by the late summer of 1941. With the carrying capacity thus reached, the management was faced with the necessity of regulating the population to avoid over-utilization. Consideration was given to trapping and transplanting the excess deer to other parts of North Dakota, but this proved impractical and a managed hunt was held. State officials cooperated with the Fish and Wildlife Service and permits to hunt on the refuge were issued. This resulted in 504 hunters taking 393 deer in a four-day season, November 22–25, 1941. The State open season on areas outside the refuge extended until December 19, and in that period an estimated additional 50 to 100 deer were eliminated from among those using the refuge. Thus at least 500 animals that would have wintered on the Lower Souris Refuge were removed. A census by state officials following the close of the State season revealed not more than 600 to 750 deer, widely scattered, on the refuge. Management of the white-tail on this refuge must always consider the ease with which the animals move on and off the area. By the late summer of 1942 the "potential" wintering population of the refuge was estimated at 1,300 to 1,400 animals. It was obvious that a reduction of this rapidly increasing herd was imperative to maintain a population within the carrying capacity of the habitat, and in the autumn of 1943 provision was made for a second special season. News of the successful hunting in 1941 was widespread, and on November 26, 1943, 800 hunters removed 575 deer, thus slightly exceeding the 500 quota established for the hunt. Approximately 510 deer remained following this one-day season.

Several management features have helped make the Lower Souris Refuge particularly attractive to deer. These include extensive food and cover plantings, cooperative farming of grains, and the timber management program. The latter provides much browse, particularly ash, a favored food of the deer in winter. Deer have made wide use of the corn, wheat, and barley left in the refuge fields for emergency wildlife feeding under the cooperative cropping program.

The white-tailed deer has shown a constant increase on the Upper Souris National Wildlife Refuge, Renville and Ward counties, North Dakota, since its establishment in 1935. Like the closely associated Lower Souris Refuge, it is along the Souris River, but on the the upper reaches of that stream just after entering the United States from Canada. The primary purpose of the Upper Souris Refuge was to impound a large body of water to supply marshes along the Souris River and restore the waterfowl breeding grounds of that region, and also to prevent the spring floods and flash runoffs that characterized the locality previous to construction of the reservoir. The water stabilization resulting from the impoundment work produced a marsh 8 to 10 miles in length and the water table in the entire countryside was raised many feet.

The value of the refuge to deer is well illustrated by the rapid increase of from 10 in 1937 to well over 500 in 1943. The tendency of the deer to concentrate in the coulees in winter subjects the browse plants there to overutilization. As the population neared the carrying capacity of the refuge, a hunt was planned for the autumn of 1943, in cooperation with state game officials. The 300 hunters who were issued permits removed 187 deer from the refuge in two days. The combined deer kill on and near the refuge during the State open season reached an estimated 280, thus greatly reducing the population on the refuge in that year. The hunting season was considered satisfactory in effecting the desired reduction. Deer have made good use of the cooperatively farmed fields on the refuge; the cropping plan is arranged so that the extensive stands of wheat, corn, barley, and millet are readily available to deer and other wildlife, without overcrowding of the animals. During the late afternoons the whitetails are often seen feeding and resting in the sweet clover stands.

The large marsh and the permanent water supply undoubtedly have been major factors in attracting deer to the Sand Lake National Wildlife Refuge, Brown County, South Dakota. This refuge, extending approximately 16 miles along the James River, a short distance below the South Dakota–North Dakota line, offers little tree or shrub cover. There are few wooded areas save isolated groves left from former farm homes and shelterbelts planted by the Service after acquisition of the area in 1935. No deer had been observed for several years preceding the establishment of the refuge, but by 1938 an occasional individual was present and in 1939 deer were using the refuge regularly, particularly during the hunting season. Four fawns in 1940 indicated breeding in the vicinity. Greatly increased numbers were seen in 1941 and following seasons. The deer have shown excellent adaptation to the marsh conditions and are seen to frequent the brakes and swamps. When startled in the marshes they drop and lie quietly among the tall reeds rather than bounding away as is usually the case. Sand Lake Refuge is serving as a game reservoir for the region since reports have been received of deer at some distance from the refuge on areas where they have not been seen in many years. The numbers appear to have reached the carrying capacity of the area and during 1942–44 there has been constant

migration from the refuge to nearby areas affording suitable habitat.

During the early winter of 1943–44, 30 white-tailed deer were seen picking their way carefully over the ice of Waubay Lake to enter the Waubay National Wildlife Refuge, Day County, South Dakota. They were leaving timbered lands on the opposite side of the lake for similar habitat within the refuge, presumably attracted by the better protection and food supply. Considerable movement on and off the area occurs and deer are seen as far as 10 miles away. The population reaches its largest numbers during the autumn and winter and decreases in summer, although some fawns are born on the refuge. The first yarding occurred during January to March, 1943, and 97 deer were counted in and near the yards on February 23, 1943. There is little browse outside the refuge boundaries and deer seen at long distances from the area in summer are thought to return to it in winter. Cultivated grains and other crops are popular with the animals, and good use is made of corn grown near the wooded areas. Alfalfa hay also is a favored food and one cooperator through failure to remove his crop in 1943 contributed about 25 tons to the deer in that winter.

The appearance of two white-tailed deer at the headquarters of the Medicine Lake National Wildlife Refuge, Roosevelt and Sheridan counties, Montana, in June 1943, were the first of the species seen since the refuge was established in 1935. According to local reports this was the first record in the locality for several years. Additional records were obtained for the sandhills and other scattered parts of the refuge during that summer. In the summer of 1944 five were noted near refuge buildings. Viewed optimistically, and in the light of events in the North Dakota areas, these might well be the nucleus of a new herd for the refuge, which is on the western edge of the range of the plains white-tailed deer (*O. v. macrourus*).

The response of the white-tailed deer to these prairie refuges emphasizes the fact that wildlife, if not too drastically reduced, can satisfactorily increase within its normal range without expensive and often unsatisfactory restocking, provided the essentials of: (1) food and cover, (2) protection from excessive predation and overshooting, and (3) permanent water supply, are available or provided.

SUMMARY

1. Reduction of white-tailed deer in the United States resulted from the curtailing of their habitat and from overshooting.

2. The Great Plains National Wildlife Refuges provided both suitable habitat and shelter, thus contributing directly to the increase in deer populations.

3. Management of the deer entails not only securing their increase, but also maintaining their numbers at a level compatible with the available food supply.

THE WILDLIFE SOCIETY

Report of the President

During the past year, when I was honored by being selected to serve as President of the Wildlife Society, I had an opportunity, as never before, to become intimate with the functioning of our organization. I had planned to speak of this to the members assembled at our annual meeting, to tell something of the impressions I gained while participating in the business of the Society. Since we had no meeting I wish to use the Journal for that purpose.

First I want to pay tribute to the members of the Council and to the Editor and the committees for their earnestness of purpose and obvious desire to further our objectives. Sometimes we did not accomplish all we desired because of war conditions, but everyone tried. I am personally grateful to our energetic secretary, P. F. English, and our Treasurer, Douglas E. Wade, who handled the bulk of the Society's work, including much that I should have done.

Immediately after the election a year ago I received a number of letters from public spirited members, giving their views on our activities—earnest letters that revealed sincerity and a feeling of responsibility for the progress of our Society. Throughout the year there has been much correspondence of a similar nature, on the particular objectives for which we work. For example, the following: "I am not sure that too many of the members of the W. L. Society know what the society is for—I am not sure myself, except that we put out a Journal that is a *leader*. It is time we started to define more carefully the purpose of our Society. Just how we'd go about this I do not know." Such correspondence has been the most heartening experience during the year.

Looking back to those uncertain days when a group of us organized the Society of Wildlife Specialists, I recall some doubts as to what would come of it, what particular outlook such a group would have, what it could amount to. But certain enthusiastic ones had the vision and the perseverance, and eventually the temporary organization became The Wildlife Society. We all know the rapid growth we have made.

Now, with a good, ample membership, some are beginning to question: What are we? Just what are we trying to do? The answer lies partly in the character of our membership, partly in the character of wildlife problems as they unfold in these changing times. As for the first item, I do not know where we can find an organization of such varied membership, unless it be a political party. There are many societies concerned with some particular group of animals, and these are conscious of fellowship bound by unity of special interest. But we have *everything* in common, everything that crawls, flies, runs, swims, or just grows. We are ornithologists, mammalogists, entomologists, ichthyologists, or botanists, and often affiliated also with other technical societies concerned with the individual compartments of biology; we are research men, administrators, teachers, or conservationists; we are state em-

ployees, federal employees, private employees, or independent workers; we are interested in game, song birds, wilderness, fisheries, range research, and such a multitude of phases of the out-of-doors picture that I would not attempt to enumerate them. Fortunately, we maintain our group on the standard of a profession. But what a conglomeration of interests!

To me this very fact is most significant. It is testimony to the hold that wildlife values have on us all; it explains some of the questioning of our goal, and undoubtedly the situation holds for us both a great promise and a challenge. The promise lies in the fact that we have in common a concern for wildlife, an understanding that it needs conservation and some kind of management, and our strength *could* lie in the very fact of our diversity of interests, covering all fields of biology, penetrating to so many minority groups—a promise of effective action if our interests and actions can be integrated. The challenge is to our ability to so integrate our efforts. Are we wise enough to see that a democracy is composed of many minorities, each with its particular kind of enjoyment and interest in wildlife and wildlife environment? I believe we have made progress in that direction.

In our technical sessions at the annual meetings there has always been an obvious effort to diversify the program so as to include the particular interests of our component groups. Where the latter are far apart in subject matter, they have been placed in different sessions running concurrently. We have struggled valiantly in our efforts to satisfy all elements in our mixed membership. I am familiar with the time and effort put on the problem of the technical sessions by Lloyd Swift and his Committee on Arrangements this past year. If anyone doubts the intricacy of the problem, let him tackle that job.

Many have expressed themselves on this question, and opinions have been varied and to the point; some of the ideas presented were: We should strive for the highest type of scientific paper, worthy of a professional society; we should have more papers on original research; we should not have "rehash"; yes, we should have "rehash," provided it is "good stuff," because of the general nature of our audiences; and there were other variants of these themes.

I believe there is much to be said for several viewpoints, but I am not sure just what is best. Certainly there can be no disagreement on the need for the highest quality in our papers. We should not have hastily assembled material of dubious value. Whatever the content, the papers should be authoritative and, above all, interesting.

I would like to refer to an article that bears directly on this question. In "Biological Symposia," Volume II, The Jaques Cattell Press, 1941, Dr. Francis B. Sumner presented a paper on "The Naturalist as a Social Phenomenon." The occasion was a symposium at Monterey, California, on the biological basis of social problems, and Dr. Sumner was referring to a society of naturalists when he said: "A society is at least conceivable having as its primary object the presentation of programs calculated to be intelligible and interesting to all members of a diversified audience such as the present one. By this I do

not have in mind providing popular programs for the laity. That is quite another problem. I am thinking of ourselves. I have in mind the need among workers in diverse branches of biology, for cultivating and extending such common ground as still remains to us in spite of our increasing specialization."

Dr. Sumner's paper has much that is worthy of our attention, and I recommend it for thoughtful reading, particularly by those who may be concerned with assembling our programs. We seem to have a dual problem, first, to interest our fellow workers in the latest technical progress in a field mutually understood; second, to interest others of our group, who may be administrators, or who in diverse ways desire chiefly to apply the findings of technicians. Science can not ignore the public, at least the interested public that is actively utilizing the findings in our field. Several have remarked on the appalling ignorance of some wildlife administrators. We simply have not reached them with our information. Unless our findings eventually go into practice our efforts are futile. I am not arguing here, any more than Dr. Sumner did, for "popularizing" our papers, or for cheapening our program in the slightest degree. But there may be room for assembling information on a problem, even though it may not be the result of recent experiment, to point up its applicability and importance, and to present it convincingly. The whole answer to this question is not clear and deserves our most careful and unbiased study.

At our annual meeting in 1944 a report was presented by E. Laurence Palmer as Chairman of the Joint Committee on War Program in Wildlife, affiliated with the National Research Council. So far as I can determine, the twelve recommendations of this committee have not received the serious attention that they deserve. This past year the committee was given a problem so comprehensive in scope by the National Research Council that little progress has been made so far. I refer to the alarming decrease in alfalfa seed crops in some western states. Some authorities believe this is due to a decided decrease in insects caused by the greater use of insect sprays to protect various crops, and bee-keepers have also been concerned. I wish to stress the fact that such problems, as well as the recommendations of this committee in 1944, are proof of the far reaching ramifications and scope of interest within the organization we call The Wildlife Society.

I would like to quote from another letter that illustrates the kind of groping for an understanding of our purpose that is becoming apparent in our membership. This is from our Treasurer, Douglas Wade:

"We have become twisted up in the social, economic, political, and natural forces that seem to determine the fate of much wildlife, and our lives. As a group, we should be the enlightened leaders and not a bunch of bogged-down technicians. My plea is that we consider deeply the social implications of wildlife management and strive constantly to bring to the fore a group of research men, administrators, and field men who have the broadening touch of true liberal education upon them. ... We should take keen joy in perfecting our technics and tools, but if we lose sight

of the changes we can effect in human lives, in plant and animal lives, and in the over-all landscape of America, then we have failed to be a society with vision".

With this statement as a background, let us look at Europe. Our soldiers are having a chance for comparisons. My son writes from Italy: "As for seeing a chamois I have scant hope. You see, these mountains are civilized from top to bottom and hardly a piece of ground is left untouched." He remarks that the ground is "completedly used and walked over, looking all worn out" and he longs for the fresh forests of America.

I earnestly recommend that we review papers on European conditions such as those by Tracy I Storer on "Relations between man and birds in western Europe" (The Condor, March-April, 1938) and by Aldo Leopold "Naturschutz in Germany" (Bird-Lore, March-April, 1936). These give an opportunity to reflect on what has happened to wildlife in Europe, and what may be possible on our own "newer" continent. So far as I know there was no "Wildlife Society" in Europe when the course was being set for the present state of affairs. The modern wildlife management concept as we know it is so recent that we can discern its beginnings within our own life span. Leopold has reported on recent pre-war efforts in Europe to restore some of the original fauna, even to the raising of owls for reintroduction into certain countries where the people missed them, once they were gone. We still have most of our fauna. We are very careless of it, because we still have it. But we still have a chance to shape the future. How wisely?

I do not recommend that we of The Wildlife Society become a propaganda organization, or go into politics. We are professional men; we have accepted a respnsibility to Science, with all the dignity and integrity that implies. We have achieved recognition by having become affiliated with the National Research Council. We have made an excellent beginning. Before us lies the opportunity for brilliant research in the management of a fauna and flora that we *still have*.

We do not need to emulate the perfect juror. We are or should be active citizens, voting, taking part in the social evolution of our country. There is no place here for withdrawal into an ivory tower. The very meaning of management implies "doing something about it" and certainly implies integrating our purely biological findings with the life of Americans. We cannot escape that.

Does not this demand that we outline courses of study for new recruits in our universities, to insure they are at least exposed to liberal education in the best sense of the word, to instill in their minds the concept of ecology in its broadest implication, and to make certain they have a high concept of our social problems, as presented by our best thinkers? Does it not also mean that we be guided in our work and recommendations by the broadest concepts of what our wildlife field consists of and what it can do for mankind?

I have stressed the miscellaneous character of our organization. I do not mean "miscellaneous" in the sense of the rag-tags or left-overs. Each element in this group is important and has a strong backing among the people of

our country. All of these varied elements have joined us with an expectation of some recognition. Some of the well known groups variously represent the national forests, that comprise so large a part of the highest type of wildlife environment and hunting fields; the national wildlife refuges, that are so helpful to much of our wildlife; the sportsmen, representing an enormous part of our population, and the state game departments that are so intimately concerned with the sportsmen; the national parks which reprecent a distinct land use, supported by a large part of our population, and which are being established also in other countries; the fisheries interests, closely integrated with the sportsmen; the wilderness enthusiasts; the dude ranch patrons, the educators, the Soil Conservation Service, the Grazing Service, Audobon Society the others in an almost endless list.

This is the scope of our field. For success it is imperative that we recognize the component interests in our organization, cooperate with each, and in sympathy with their objectives. Uniformity is the aim of the dictator. Democracy is made up of minorities, among which each one is given recognition and reasonable satisfaction. Herein lies the opportunity and the challenge for the Wildlife Society.

O. J. MURIE, *President*

REPORT OF THE SECRETARY FOR THE YEAR ENDING APRIL 15, 1945

Since the last regular meeting of the Society held at Chicago, April 24, 1944, a number of things have happened. First and foremost was cancellation of the annual North American Wildlife Conference scheduled to be held in New York City on February 26 to 28. This resulted from an order by the Office of Defense Transportation to cancel all meetings, with an attendance of more than 50 persons, not absolutely essential to the war effort. The cancellation also eliminated the annual business meeting of The Wildlife Society and has necessitated carrying on our business by mail. A report of the business transacted appears elsewhere in the Journal. The war has not caused the work of the Secretary to wane; rather the business of the Society is on the increase.

The total membership in good standing for the year ending April 15, 1945, was 824, comprising 388 Active Members, 432 Associate Members, two Life Members, and two Honorary Members. In addition 217 libraries, offices, and individuals subscribed to The Journal of Wildlife Management. To these figures will be added many who frequently are late in paying their dues and many tardy subscriptions. The Secretary would again like to emphasize that the work of both the Treasurer and Secretary would be aided greatly if the members would pay their dues in November and December for the next year; as of April 15, 1945, there were 65 Active Members and 113 Associate Members of 1944 who had not paid their 1945 dues. The Treasurer has worked close with the Secretary and business has functioned rather smoothly. The members and subscribers can be of great assistance if they will notify the Secretary *promptly* on change of address.

The Secretary has had the pleasure of taking in members of the armed services while these men were engaged in battles for their lives. Applications have come from Saipan during that campaign, from the Philippines, from Italy, and from aboard ships. Both the Secretary and Treasurer have been solicitous and have taken time to write all these men letters that under other conditions would have been mere formal notes. The boys show their appreciation and some mighty fine correspondence has developed out of what at first was routine business.

Eight members have resigned during the past year, in most cases due to retrenchment. Some have retired and feel they must reduce expenses. During the year, we gained 52 Active and 61 Associate Members, and 33 were raised from Associate to Active Status. We have 19 members who do not reside in continental United States; most of them are Canadian friends. Two became Life Members during the past year, Ralph Ellis a former Associate Member and L. E. Hicks an Active Member. There were 18 Active and 67 Associate Members in good standing as of December 31, 1943 but now in arrears for two years; and many of these will be lost to the Society for non-payment of dues. A number of libraries have purchased complete sets of the Journal during the year.

The Regional Representatives and other officers of The Society who make up the Council aided your Secretary in the conduct of business matters during the past year. The response on pertinent matters was usually prompt and the Secretary wishes to thank each for his part.

An issue of the Wartime Newsletter of The Wildlife Society was published during June, 1944, and another was released on February 1, 1945; both were under the direction of Victor Cahalane and R. E. Trippensee.

The Secretary compiled the annual list of members in good standing for 1944, which was published in the October 1944 issue of the Journal. Subscribers' names do not appear in the list. Many individual subscribers should avail themselves of the opportunity to become Associate members of The Society.

During the past year we lost twelve members by death—Active Members: Russell M. Berthel, Minnesota; Arthur L. Clark, Missouri; C. K. Cooperrider, Arizona; W. Carl Gower, Michigan; W. S. Long, Utah; Orange A. Olsen, Utah; H. L. Van Volkenberg, Texas. Associate Members: Robert M. Giegler,* New York; Paul B. Riis, Illinois; Dayton Stoner, New York; John A. White, New York; Philip C. Walton.* In addition, Robert Ward Allen,* Iowa, and Albert E. Miller,* New York, lost their lives in service during 1943, but we did not learn of their deaths until the past year. (* In armed forces.)

Frank C. Edminister helped obtain a number of new members during the past year and the Secretary made a modest drive for new members.

The Officers and Regional representatives elected for 1945–46 by mail ballot (see report of ballot committee) are as follows: President, Lee E. Yeager; Vice-President, Gustav A. Swanson; Secretary, P. F. English; Treasurer, Douglas E. Wade; Regional Representatives: Region 1, John Pearce; Region 2, V. E. Davison; Region 3, Warren W. Chase; Region 4, E. R. Kalmbach; Region 5, Walter P. Taylor; Region 6, P. R. Needham.

P. F. ENGLISH, *Secretary*

REPORT OF THE TREASURER FOR THE CALENDAR YEAR 1944

Early in November last your Treasurer sent out 1,209 dues statements and 283 subscriber invoices. Also, in concurrence with a request of the Council, second and third successive dues notices, each with a special letter, were mailed to members delinquent one or more years. The results from these notices have been satisfactory.

During 1944 the Society gained two Life Members, and the Council has been giving thought to the establishment of a Permanent Trust Fund.

Your Secretary and Treasurer have schemed during the past two years to lessen the office "chores," to eliminate possible sources of error and irritation, and to obtain more complete records of the wartime activities of all members. There has been much grief, wrought primarily by war, but it has been encouraging that there have been some notes of pleasantry.

The bank balance at the end of the year was the best in our history. All other facts usually reported by the Treasurer are set forth in the annual Financial Statement.

DOUGLAS E. WADE, *Treasurer*

FINANCIAL STATEMENT

For the Calendar Year 1944

Balance (December 31, 1943)	$2,972.17	
Receipts (dues, subscriptions and sale of back numbers)	6,148.45	
Total Balance and Receipts		$9,120.62
Disbursements:		
General Administration		
Stationery and printing	$ 213.28	
Postage, telegrams and express	88.98	
Clerical assistance	20.30	
Checks returned and collection charges	8.35[1]	
Treasurer's expenses and fidelity bond	13.65	
Editor's expenses	25.00	
Reimbursement on subscription	2.00	
Purchase of back issues (second-hand)	5.00[2]	
Publications		
Journal of Wildlife Management (4 issues)	2,635.81	
News Letter (one issue)	53.23	
Other appropriations		
Biological Abstracts	50.00	
Total Disbursements		$3,115.60
Balance (December 31, 1944)		$6,005.02[3]

Signed: Douglas E. Wade, *Treasurer*
The Wildlife Society

[1] Includes two checks ($8.00) received again later and redeposited.

[2] Check outstanding at end of year, but included in books; hence bank balance on December 31, 1944, actually $6,010.02.

[3] Funds on deposit in Dartmouth National Bank, Hanover, New Hampshire.

REPORT OF THE EDITOR

Volume 7 (1943) of the Journal of Wildlife Management comprised 428 pages and 25 plates, with 52 longer and 18 briefer articles, 5 reviews, 4 obituaries, and the annual reports. Volume 8 (1944) of 348 pages and 18 plates contained 37 longer and 18 briefer articles, 3 reviews, and the annual reports, together with the membership list of 18 pages.

The continuing entry of younger members into the armed forces and other war activities and the resulting increased duties of persons remaining in wildlife work are reflected in the lessening supply of manuscripts for the Journal. Many of the recent contributions were based on the studies by younger investigators and either written up by them before departure or finished by the persons under whom they worked. Even the supply of such papers is declining. Since the initiation of new investigations in numbers must await the coming of peace, there may be a dearth of articles for the Journal in the years immediately ahead.

In general, the manuscripts submitted have been of materials and of a form suitable for the Journal. In any doubtful case, all three members of the editorial staff read and appraise a manuscript, and the final decision as to suitability is based on their collective opinion; only a few have been rejected. Of the accepted manuscripts, however, many require extensive editorial attention before being sent to the printer, and a limited number must be returned to the authors for reworking. If authors, when preparing manuscripts, would examine recent issues of the Journal as to matters of physical style and then would read carefully and follow the "suggestions" printed on cover page 3 of the Journal, much editorial labor would be saved. In preparing manuscripts for the printer, the Editor has sought to conserve publication expense and paper (which is rationed). He also keeps in mind the time and convenience of readers of the Journal and believes that undue repetition of detail in the text is a hindrance rather than a help. Through the years his own efforts in writing have been subjected to the blue pencils and shears of various editors—with decided profit—and he seeks to serve similarly for the Wildlife Society.

Fortunately the supply of manuscripts has been sufficiently diverse in subject matter to engage the interests of the various categories of members and readers. In one field, however, the supply is too short, that pertaining to fish and fisheries. We have many working or interested in these matters but relatively few manuscripts have been submitted. Members can help to improve the situation by encouraging the submission of appropriate manuscripts dealing with aquatic resources and aquatic species.

TRACY I. STORER, *Editor*

REPORT OF THE BUSINESS MEETING OF THE COUNCIL

With the cancellation of the annual North American Wildlife Conference, the business of The Wildlife Society had to be conducted by mail. The officers prepared material which the President worked into an agenda and this was circulated on March 21, 1945 to all Council Members by the Secretary, who also handled some matters by memoranda to the Council. Members of the Council were instructed to return their comments to the President and Secretary by April 6; by April 20, seven returns had been received, including those of the President and Secretary. This report summarizes the business transacted.

For the Membership Committee, Herbert L. Stoddard was reappointed, Lloyd L. Smith (vice Phil Goodrum) was appointed for a full term, and D. I. Rasmussen (vice Arthur L. Clark, deceased) was appointed for a full term; P. F. English was designated as Chairman of the Committee.

The Council voted to retain Herbert L. Stoddard as Trustee.

Tracy I. Storer, who in the opinion of the Council is doing a splendid work in editing The Journal of Wildlife Management, was unanimously reappointed as Editor. Under discussion of editorial policy, a canvass of the Council showed general agreement with the Editor's proposal to retain our standards of quality even though there is a scarcity of papers for The Journal and that it is better to reduce the size of The Journal if necessary. There was general concurrence that we might give space for articles on the objectives of our Society and similar subjects having to do with general considerations affecting our work, presumably still maintaining quality as in any technical paper. It is felt, also, that in times such as the present, The Journal can serve as a medium for reporting to the general membership on all business transacted by the Society. The opinion also was voiced that longer papers, with somewhat less severe editing to conserve space, could be accepted this year, in view of the shortage of articles. All agree, however, to keep present standards of quality.

The Council agreed that $2,000 may be set aside for investment and most of the members favored buying War Bonds.

The Treasurer sent a memorandum to the Council regarding off-set reprinting of scarce or near out-of-print issues so that a fair stock of complete volumes will be available; this was favored by the Council. The Council also decided to purchase complete sets where possible from persons who have dropped their membership, if these can be had at reasonable prices. Such sets would then be available for resale to other members.

The Awards Committee agreed that a dual award should be made for 1944—to Albert H. Hochbaum, author of "The Canvas-back on a Prairie Marsh" and to Durward L. Allen, author of "Michican Fox Squirrel Management."

The following resolution received unanimous and enthusiastic approval, and the President has forwarded a copy to the U. S. Civil Service Commission:

Whereas, it has come to our attention that the Veterans Preference Act, Public

Law No. 359, 78th Congress, Section 5, contains the following clause:

"No minimum educational requirements will be prescribed in any Civil Service examination except for such scientific, technical, or professional positions the duties of which the Civil Service Commission decides cannot be performed by a person who does not have such education."

Whereas, we have been informed that the Civil Service Commission is disposed to rule that the only positions for which specific educational training is prerequisite are those for which such training is specified by law, as it is for physicians and veterinarians;

Whereas, such dropping of professional standards would seriously impair the quality of American scientific work in the post-war years; and

Whereas, The Wildlife Society, as well as many other professional societies, have now in the military forces numerous members who have spent years of training for various phases of wildlife management, not to mention other professional fields, and who are now sacrificing some of the best years of their lives on the battlefield; now therefore, be it

Resolved, that we, the members of the Wildlife Society, urge the Civil Service Commission and Congress to so clarify the clause in question in the Veterans Preference Act, to permit the retention of adequate minimum educational requirements to protect the rights of returning trained veterans and to insure adequate standards in American professional endeavors.

On the matter of honorary membership for seven persons whose names were submitted, the votes were so scattered among the candidates that it was difficult to determine just what majorities would represent the consensus of the Council. It seemed best to refer these names to the new Council for future action, if any.

Nearly everyone seems in favor of putting out a manual of wildlife technics under the direction of Dr. Cottam's division in the U. S. Fish and Wildlife Service, but there were several qualifying statements as to procedure. This question, together with the opinions expressed, was referred to the new Council for action.

Eight of nine members of the Council were in favor of setting up a new region for Canadians, *if* the Canadians desire it. The next step is to ascertain the wishes of the Canadian members.

Eight of nine were in favor of the Wildlife Society sponsoring an educational forum at the annual meeting; the seventh member was noncomittal at this time.

The vote was unanimous for allowing $50 for the clerical work performed for the Secretary by Miss Sutter. Eight of nine voted a similar sum for clerical help for the Treasurer and Editor.

A proposal to require additional qualifications for life membership was definitely rejected. It was proposed that each Editor of the Journal of Wildlife Management be presented with a bound set of the Journal; a majority were in favor of the proposal, but there was enough difference of opinion to consider this an item of business that is not urgent enough to pass upon without a more complete expression of opinion from the Society.

In conducting the business of the Society in this manner (not strictly in accordance with regular procedure), we trust that the members will understand the necessity of taking some kind of action, and doing the best possible under the circumstances.

O. J. MURIE, *President*
P. F. ENGLISH, *Secretary*

REPORT OF BALLOT COMMITTEE

The committee reports the following audit of the nomination and election ballots for The Wildlife Society for 1945–46:

1. NOMINATION BALLOTS. Total mailed to voting members, 403; returned, 119; late, 10; counted 109, as follows: Region 1, 34; Region 2, 5; Region 3, 36; Region 4, 6; Region 5, 9; Region 6, 19. These checked with the tally by the Secretary and gave the following results:

President: 53 persons nominated; two highest, L. E. Yeager, 99; T. H. Langlois, 31. (O. J. Murie received 51 votes but according to the constitution the President cannot succeed himself.) *Vice-president:* 81 persons nominated; two highest, D. I. Rasmussen, 53; G. A. Swanson, 34. (L. E. Yeager received 38 votes but according to the constitution the Vice-President cannot succeed himself.) *Secretary:* 47 persons nominated; two highest, P. F. English, 288; R. E. Trippensee, 13. *Treasurer:* 57 persons nominated; two highest, D. E. 255; P. D. Dalke, 21.

Regional Representatives: Region 1, 27 nominations; two highest, John Pearce, 39; H. L. Mendall, 19. *Region* 2, 5 nominations; two highest, V. E. Davison, 5; Phil Goodrum, 4. *Region* 3, 29 nominations; two highest, W. W. Chase, 36; H. W. Olds, 21. *Region* 4, 7 nominations; two highest E. R. Kalmbach, 12; H. W. Mills, 4. *Region* 5, 8 nominations; two highest, D. W. Lay, 11; W. P. Taylor, 7. *Region* 6, 20 nominations; two highest, P. R. Needham, 22; G. H. True, Jr., 10.

2. ELECTION BALLOTS. Total mailed to voting members 403; returned 261, as follows: Region 1, 70; Region 2, 21; Region 3, 87; Region 4, 15; Region 5, 22; and Region 6, 46. Officers elected were: *President,* Lee E. Yeager; *Vice-President,* Gustav A. Swanson; *Secretary,* P. F. English; *Treasurer,* Douglas E. Wade.

Regional Representatives: Region 1, John Pearce; *Region* 2, Verne E. Davison; *Region* 3, Warren W. Chase; *Region* 4, E. R. Kalmbach; *Region* 5, Walter P. Taylor; and *Region* 6, Paul R. Needham.

We find the above correct and final as of April 12, 1945.

THE COMMITTEE:
GORDON L. TREMBLY, Chairman
MERRILL WOOD
E. W. CALLENBACH

BRIEFER ARTICLES

RATIO OF REPORTED TO UNREPORTED DUCK BANDS IN ILLINOIS

In wildlife management it is frequently desirable to ascertain the proportion of a game population taken by hunters. One method is to compare the population with the kill and another is to ascertain the percentage of a marked population killed.

It is often impossible to census a game population accurately, or even to make a close estimate, and frequently it is just as difficult to obtain adequate records of the kill. Marking or banding also has disadvantages because (1) the sample must be random and sufficiently large to be statistically significant, and (2) all marked or banded animals killed must be recorded or accounted for.

From band returns we may judge the minimum percentage of a population taken by hunters, but since some banded birds are bagged but not reported, it usually is impossible to determine the total percentage taken. The writer has found no published statement on the proportion of banded birds which are shot and reported other than one by McIlhenny (The Auk, 51: 328–337, 1934) to the effect that: "I think, fully 50 per cent of the banded birds shot are reported to the Biological Survey."

Late in 1944 the writer made a survey among Illinois duck hunters to determine the percentage of banded ducks bagged which are not reported, by sending 1,000 double post card questionnaires to Illinois duck hunters. The names and addresses were selected at random from game kill record cards sent to the State Department of Conservation. In all, 509 postals were returned. Sixty-four hunters (12.6% of returns) reported having killed banded ducks in Illinois in 1943 or 1944, or both years; 14 (22% of those reporting having killed banded ducks) had not reported bands taken, and three of the remaining 50 had reported some bands but not all. We estimate that about 77 per cent of the bands taken by the 509 hunters answering the questionnaire had been reported. Was this percentage representative for all Illinois duck hunters?

Club hunters reported 82 per cent of the bands they took and non-club hunters 74 per cent. Both club and non-club waterfowlers include business and professional men, laborers and farmers, but the former predo ıte in the club group, and the laborers and farmers, less accustomed to making reports, in the non-club group.

Bellrose (Illinois Nat. Hist. Surv. Biol. Notes, 17, 1944) found about 12 per cent of Illinois waterfowlers hunt at clubs, yet 19 per cent of the 509 cards returned were from club hunters. This difference probably resulted from a greater proportional response by club hunters, both in sending their game kill cards to the Department and in returning our questionnaires.

Correcting for this discrepancy in the sample, we find that Illinois hunters reported about 75 per cent of the duck bands they have taken in recent years. This may be slightly higher than the general average over North America because we made a special effort, by placards and newspaper releases, to obtain band returns. Pending additional studies we may assume that about 75 per cent of the bands taken from ducks shot by hunters (excluding Indians) in North America are reported.

Applying this percentage to figures supplied by B. W. Cartwright of Ducks Unlimited, Canada, on the number of ducks banded on the breeding grounds, and to the number of band returns from these birds in their first season after being banded, we calculate that hunters bagged the following percentages of the duck population: 8.4 in 1940, 7.0 in 1941, and 9.4 in 1942. These do not include ducks killed or crippled but unretrieved. Studies in Illinois indicate that such losses amount to at least one-third of the birds bagged. These figures may be revised after further study, but we may assume that waterfowlers now kill annually about 11 per cent of the continental duck population.—FRANK C. BELLROSE, JR., *Illinois Natural History Survey, Urbana, Illinois.*

VISCERAL GOUT A SYMPTOM OF A-VITAMINOSIS

The symptoms noted by Cowan and Fowle (Journ. Wildl. Mgt., **8**: 260–261, 1944) in a wild ruffed grouse are identical with those found by Nestler and Bailey (*idem.*, **7**: 170–173, 1943) in bobwhite quail (*Colinus virginianus*) that have died on diets deficient in vitamin A. Current studies at the Patuxent Research Refuge convince us that visceral gout is a positive symptom of this deficiency in the bobwhite, although it is not present in all cases. Even on a maintenance diet containing 11 per cent protein, the condition is manifested when vitamin A is omitted; but it does not appear when a level of the vitamin as low as 500 I. U. per pound of feed is included, even with the birds under close confinement or without green feed.

Bushnell and Twiehaus (Kansas Agric. Exp. Sta. Bul., **284**: 24–31, 1939) have definitely associated visceral gout with vitamin A deficiency in poultry. In discussing A-vitaminosis (nutritional disease) they state that: "In addition to the nodules in the esophagus, birds suffering from nutritional disease may show very characteristic changes in the kidneys. They appear enlarged, pale in color, and streaked with a network of white lines. These lines are due to the presence of excessive deposits of urates. Occasionally a general distribution of urates occurs throughout the body on the surface of the intestinal organs and on the heart which appears as if sprinkled with a white powder. In young birds the bursa of Fabricius becomes distended with a white exudate."

Cowan and Fowle refer to Biely's personal communication relative to visceral gout among birds that apparently were fed a balanced ration "well fortified with vitamin A." It would be desirable to know three things about the diet: (1) the level of vitamin A used; (2) the form of vitamin used, whether true vitamin A or its precursor, carotene; and (3) the physical character of the diet, whether finely ground or coarse, and whether fed as entire or cracked seeds so that selection could be exercised by the birds. These considerations are very important in an analysis of the results. At the Patuxent Refuge, severe A-vitaminosis accompanied by visceral gout occurred among bobwhite quail that had received a seed mixture containing dehydrated alfalfa leaf meal as the source of carotene. The alfalfa was scrupulously avoided by most of the birds. Also it has been found that carotene is not utilized by bobwhites as efficiently as true vitamin A. It is to be hoped that the Canadian workers will conduct investigations with ruffed grouse to determine whether vitamin A deficiency might be the underlying cause of the visceral gout in that gallinaceous species, as it appears to be in the bobwhite quail.—RALPH B. NESTLER, *Economic Investigations Laboratory, Patuxent Research Refuge, Bowie, Maryland.*

FLUSHING TUBE FOR DETERMINING FOOD OF GAME BIRDS

A knowledge of the food habits and preferences of game species is important to the wildlife manager desirous of obtaining maximum populations for a given area, especially where introductions are being made or restocking is planned.

Food habit studies in the past have been accomplished mainly by direct observation and by stomach or crop analysis from dead animals. The first method takes considerable time and effort by a trained observer, and even so has limited accuracy under optimum conditions at close range. The second is excellent for accurate qualitative and quantitative data but there often is difficulty in obtaining enough specimens for statistical analysis. For stomach or crop examinations, specimens may be obtained from three sources: accidental kills, animals killed during a hunting season, and specimens collected especially for study. Those of the first group usually yield accurate information on food habits, except when the bird has died from disease. Stomachs of birds killed during the hunting season reveal the diet for but only one part of the year, and collecting game birds for study often is frowned upon by state conservation departments and is not

always feasible. A further method is the analysis of droppings or scats. This is time consuming and may be inaccurate if done by other than highly skilled technicians. Quantitative findings may be biased in respect to certain foods, since various items in the diet are digested in differing degree.

(Fig. 1) with a standpipe at right angles to the outer tube. The two tubes are made of tinned sheet metal and soldered together at the junction of the "T"; the inner tube extends back 3 or 4 inches to carry out the crop contents and circulating water. The tubes continue forward 6 inches from the "T," and

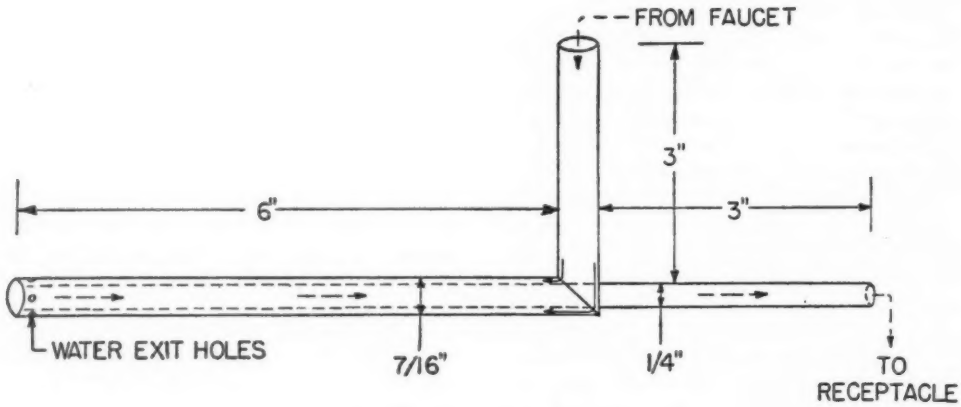

Fig. 1. Crop flusher.

If the food habits of living birds could be determined accurately for each of the twelve months, the game population would not be diminished and results would be satisfactory to all concerned. Recalling the success of the medical profession with stomach pumps and similar equipment and of the aspirator used by Nord (Journ. Wildl. Mgt., 5: 175–179, 1941) for removing lead shot from sick ducks, the writer has developed a device for flushing out the crop contents of living birds. The California valley quail (*Lophortyx californica vallicola*) was used and good results were obtained with all but one individual, which was "drowned" accidentally. The apparatus described is not necessarily the only design which will work, but is a basic pattern. Certain adaptations would be needed for larger species. Since individual methods of use can be worked out to advantage by each operator, no cut and dried procedure is formulated. The only requirements are a suitable bench, a water supply with readily controlled temperature, and a means for holding the bird firmly in place during the work.

The "crop flusher" is a tube-within-a-tube

the water is released through four holes drilled through the end of the outside tube. This end must be very smooth. The two tubes are soldered together carefully and all projecting points are well beveled with the solder. For use with quail, the outer diameter of the outside tube should be no greater than 7/16-inch and the inner tube $\frac{1}{4}$-inch in inside dimension. The space between is sufficient for the incoming water.

Water enters the standpipe through a rubber hose, passes forward through the outer tube, out through the four holes and circulates in the crop. As pressure is built up, the crop is massaged slightly with one hand of the operator and the crop contents are expelled gradually through the inside tube into a suitable receptacle. Care must be exercised to control the amount of water entering the crop, because too much will burst the thin crop wall. Before being inserted into the esophagus, the tube is lubricated thoroughly with petroleum jelly to facilitate its entry. The temperature of the water should be kept under 100°F.; lukewarm water proved very satisfactory.

Seeds and grains are readily expelled, but leafy material proved somewhat more difficult to remove. Either a sample or all of the crop contents may be taken. Quail were able to breathe normally during the operation and experienced no ill effects after having the tube in the mouth for 6 or 8 minutes. The time should be kept to 5 minutes or less if possible. One bird was killed by water being introduced accidentally into the pharynx.

Birds should be trapped in the afternoon or evening, since those taken early in the morning have the crops empty. If bait is used in trapping it should be readily identifiable so as to be excluded from the analysis.—DONALD B. VOGTMAN, *Oregon Cooperative Wildlife Research Unit, Oregon State College, Corvallis, Oregon.*

DEER FOOD PRODUCED BY ICE STORM[1]

In November 1943, central Maine was visited by a severe ice storm which bowed down or snapped off many species of forest trees. Rain and sleet froze to the tree tops transforming twigs and branches into heavy networks of ice. The storm was general in the state but produced deep snow in western Maine and ice in most of the eastern part.

On an area of northern white cedar swamp where the production of deer browse from this species is being studied, storm damage occurred in sufficient degree so that it could be measured. A tally of cedars with crowns 7 feet or less from the ground by crown classes on three study plots (which 4 years previously had received heavy cutting, no treatment, and light cutting, respectively) showed results as follows:

Crown class	*Plot A*	*Plot B*	*Plot C*
Dominant	1	1	1
Codominant	5	3	11
Intermediate	30	3	41
Overtopped	61	31	125

The tally was repeated in the autumn of 1944 when the number of stems permanently thrown and those which had righted themselves could be counted and the amount of browse made available could be measured. A tally of diameters also was taken so that the approximate weight of browse could be calculated. Trees, by crown classes, permanently thrown are listed as "down" and those down in the autumn of 1943 but which had sprung back by the autumn of 1944 are listed as "up": The trees browsed during the winter following the ice storm were as follows:

Crown class	*Plot A*		*Plot B*		*Plot C*	
	Down	*Up*	*Down*	*Up*	*Down*	*Up*
Dominant	—	—	—	—	1	—
Codominant	6	—	1	—	4	2
Intermediate	5	3	2	1	7	7
Overtopped	3	15	2	4	21	30

This second tabulation is only a conservative approximation, because it was difficult to distinguish trees which had been permanently thrown in 1943 from those which had sprung back to their original position. The tally of thrown trees of 1943 in the first tabulation is greater than those under "down" in the second.

The trees by diameter classes, including those thrown permanently and those browsed and sprung back to their previous positions, as compared with all trees on each of the three plots, were in percentages, as follows:

D.B.H. Inches	*Plot A*	*Plot B*	*Plot C*
0.6–1.5	*5.1*	*2.9*	*17.9*
1.6–2.5	*5.1*	—	*12.0*
2.6–3.5	*8.5*	*1.5*	*10.0*
3.6–4.5	*5.5*	—	*8.7*
4.6–5.5	—	—	*11.7*
5.6–6.5	—	—	—
6.6–7.5	—	*7.1*	—

The bulk of the trees affected were the weaker-stemmed, over-topped individuals easily bowed over. The soil was wet, mucky,

[1] In cooperation with Maine Cooperative Wildlife Research Unit.

and unfrozen so that root anchorage was poor; nevertheless, trees were bowed instead of uprooted.

Using the figures of available food from cedar of different diameters in a previous study (Lake States Forest Exp. Sta. Tech. Note no. 159, 1940) for a cedar swamp where a browse line existed, the trees indicated in the third tabulation provided some 1,120 pounds of cedar browse per acre. From animals found feeding on these trees, and from tracks and feces, it is obvious that deer and rabbits were prompt to discover this food supply in an area where little cedar browse otherwise is available and before the time when deer ordinarily "yard up." If the browse made available for deer were calculated on the basis of trees found within reach of deer in the autumn of 1943 after the storm, it would have been several times the above figure. Besides the "pruning" some trees received, there will result from this climatic disturbance vegetative reproduction from thrown trees which still maintain small amounts of foliage and whose root systems are reasonably intact. Contrary to newspaper stories and local theories, this ice storm actually improved conditions in east central Maine so far as current and future deer food supply is concerned. The storm was not severe on the deer themselves, since no low temperatures prevailed and the storm was of short duration.

This incident provides a striking example of the forces constantly at work on the biological balance of the forest community. These may assume either minor or major proportions, but they provide a continual procession of changes which, if observed and preferably measured, assist the forester to appreciate more fully his role as manager.—JAMES D. CURTIS, *Department of Forestry, University of Maine, Orono, Maine.*

REVIEW

Michigan Fox Squirrel Management. Durward L. Allen. Game Division, Department of Conservation, Lansing, Michigan. Game Div. Publ. No. 100, 404 pp., 152 figs.+60 unnumbered illus. October 1943 [First copies actually mailed in December, 1944]. Paper $1.25; cloth, $1.50.

Not since the appearance of Morgan's classic treatise on the beaver has there been such a comprehensive work on a single species of Michigan mammal as the subject of this review. Much painstaking labor went into the collection of data, organization of the material, and final presentation for publication. The subject matter is arranged in three parts.

Part One, "What we have to work with and how it can be used," traces changes in habitats of the gray and fox squirrels from the time white men settled in Michigan to the present. The former numbers and distribution of the two species are compared with present conditions. The natural land divisions and climate of the Lower Peninsula are discussed in relation to kinds of tree growth, and the important fox squirrel habitats are evaluated. Oak-hickory woodlots are better producers of fox squirrels than other types of Michigan woods. To familiarize the reader with fox squirrel yields under present conditions, the author gives reported kills for the four years 1939–42; the largest was in 1940 with over 725,000 and the smallest in 1941 with slightly more than 539,000 squirrels taken by hunters.

Part Two, "How the fox squirrel lives," consists chiefly of methods of study and life-history material. The latter is basic for any management program. A fall population of three fox squirrels per wooded acre is rarely exceeded—two per wooded acre is considered high. In the yearly turnover, natural mortality accounts for about one-third, hunter kill for one-third, and one-third of the pre-hunting population is preserved for breeding. Fox squirrels increased in numbers from 1937 to 1940, decreased in 1941, but reached a new high in 1942. The study was not extended long enough to determine whether the fluctuations represent cycles. Three young per litter is average. Old females usually raise two litters a season and yearling

females one litter each. The age ratio in the autumn is about 60 per cent of young to 40 per cent of adults. The average home range is about 10 acres for a season and 40 acres for the year. There is an indication of territoriality, but the information was not sufficient for definite conclusions. The longest recorded natural movement, 40 miles from the place of its birth, was for a young squirrel that was shot about three months after the first capture. One "stocked" squirrel moved about 46 miles from the point of release in unfamiliar terrain. Most of the movement from one woodlot to another takes place from August through November. The heaviest squirrel in 4,000 samples weighed 2 pounds 11.5 ounces and the average adult 1 pound 11 ounces. Staple foods are mast and corn. These are supplemented by a great variety of items. Sarcoptic mange is the most serious single factor in natural mortality, especially if linked with a poor mast crop.

A theoretically ideal habitat for fox squirrels in southern Michigan is " . . . mature oak-hickory woodland broken up into small units (possibly 5 to 20 acres), irregular in shape for maximum 'edge,' and connected with lines of trees or strips of woodland which serve as squirrel travel lanes." There should be mast trees in the open, the woodlots interspersed with thickets, and fertile fields nearby. Walnut, elm, beech, and maple are important food-bearing trees.

Part Three deals with "Management." Simply stated, management consists of habitat development and control of the kill by regulated open seasons. Suggestions are given for habitat improvement on farms and in the different types of country found in southern Michigan. Items *not* recommended for fox squirrel management are: predator control, sanctuaries, and artificial stocking in areas already inhabited by squirrels. The author discourages "nest shooting" by the hunter. Most squirrels remain in the nest and, unless the trees are climbed, this is an extremely wasteful practice.

There are 115 titles in the "Literature Cited." An appendix includes statements from questionnaires, detailed maps of the ranges of 19 different individual squirrels for the periods (two to four years) they were under observation, and a list of technical names of woody plants mentioned in the text. An adequate index is supplied.

To the reviewer, this is an extremely important contribution to the field of squirrel management in particular and to wildlife management in general. Many of the principles have wide application. It is a *must* for every wildlife technician. The many excellent photographs reproduced remarkably well on the "war time" paper used. Each was selected to bring out a particular point, and collectively they add much to the value of the book. The academically inclined reader might object to the cartoons, by Oscar Warbach, on the grounds that in this respect the book approaches the level of a Sunday comic strip, but to the reviewer they are delightfully refreshing. It should be remembered that the book was written for the sportsman as well as for the trained specialist. The diagrams of individual home ranges (p. 147) might be misleading in that the boundary lines connecting the outside points of capture possibly indicate a larger range than the data justify. The reader, however, can draw his own boundaries inasmuch as the points of capture or observation are plotted. The author and the Department are to be congratulated on a job well done.—WILLIAM HENRY BURT.

OBITUARY

Arthur Lincoln Clark

Arthur L. Clark died of a heart attack September 20, 1944, while on a pheasant hunting trip with friends near Hebron, North Dakota. He was born December 18, 1892, in Boston, Massachusetts. In the first World War he was an observer in the 24th Aerial Squadron with the rank of First Lieutenant. His plane was shot down behind enemy lines and he spent several months in a German prison camp. His son, Corporal David M. Clark, is serving in the present war.

After the war, Arthur Clark resumed his college education and was graduated in 1920 from Rhode Island State College with the bachelor of science degree, and in 1922 obtained a master's degree in conservation from Cornell University. For five years he was executive secretary of the Massachusetts Fish and Game Association and for another five years was fish and game editor of the National Sportsman and Fishing and Hunting Magazine.

Clark served six years as superintendent of the Connecticut Department of Game and Fisheries and made a distinguished record. He then went to Missouri in April 1938 to assume the important task of directing the restoration of fish, game and forest resources in that state. As chief of the Division of Fish, Game and Forests in the newly created Missouri Conservation Commission, he saw great opportunity to demonstrate his firm belief that wildlife conservation could be administered according to scientific principles and sound natural laws. As director of the Pittman-Robertson research program in Missouri, he was largely responsible, if not for the actual discovery of soil type and soil fertility as the answer to many perplexing wildlife problems, for finding a practical means of applying the principle. The key to restoration, he knew was improvement of natural environment through better land use and, with the tenacity of his will and the resourcefulness of his brilliant mind, resisted those artificial and spectacular methods which waste the sportsman's money while producing only transient benefits, if any.

Arthur Clark stood high in the ranks of his profession. In 1938 he was elected president of the International Association of Fish, Game and Conservation Commissioners. He was a divisional vice-president of the American Fisheries Society, an active member of The Wildlife Society, a member of the Izaak Walton League, and of other national conservation organizations. He was recognized widely as one of the able conservation administrators.

The following is a partial list of his important writings, which express his carefully considered views and plans.

1935. Connecticut plan of farmer-sportsman relationship. Amer. Game Conf. Trans., **21**: 71–73. (with Thos. Beck.)

1936. Restoration: management by public agencies. N. Amer. Wildl. Conf. Trans., **1**: 185–186.

1939. Cash for aiding wildlife. Missouri Ruralist, **80**(6): 5, 18.

1941. An indirect approach to wildlife conservation. Pittman-Robertson Quarterly, **1**(2): 99–105.

1942. Annual restocking-game management or public relations? N. Amer. Wildl. Conf. Trans., **7**: 179–184.

—George O. Hendrickson, *Department of Zoology and Entomology, Iowa State College, Ames, Iowa.*

SUGGESTIONS ON MANUSCRIPTS AND ILLUSTRATIONS

The Journal publishes sound original articles, discussions, and reviews on wildlife research, management, and administration. The author (or one of joint authors) must be a member of the Society in good standing; exceptions need special approval by the Editor and President (ruling of Council, Feb. 16, 1941).

In general, papers will be published in order of receipt of copy in final form. Any requiring major changes will be returned promptly. Suitability is judged by the content of significant new material, concisely stated, with scientific accuracy and clarity of expression. If necessary, enlist the aid of a local editor or instructor in English in matters of style, grammar, and punctuation. The University of Chicago "Manual of Style" (1937), S. F. Trelease and E. S. Yule "Preparation of Scientific and Technical Papers" (1936, Baltimore, Williams & Wilkins Co.), and similar manuals are helpful aids.

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The Wildlife Society was founded on February 28, 1937. Its principal objectives are: (a) Establishment of professional solidarity and maintenance of the highest possible professional standards; (b) development of all types of wildlife management along sound biological lines; (c) publications to effect these ends; and (d) protection of the interests of its members. These purposes are served by annual meetings, regional meetings, correspondence between members, and publication of the quarterly Journal of Wildlife Management and of the bimonthly Wildlife News.

Associate Membership is open to any interested person who is sponsored by two Active Members; dues are $4.00 annually. *Active Membership* (requiring election by the Council) is open to persons professionally engaged in the practice or teaching of wildlife management, in wildlife administration, in wildlife research or in graduate study of these subjects, who is a graduate of a school approved by the Council; or who, in the opinion of the Council, has acquired an understanding of wildlife work comparable to that required by an approved school; dues are $5.00 annually. *Honorary Members* are persons recognized for distinguished service or outstanding achievement in wildlife management. All classes of members receive The Journal and News. Applications for membership should be made to the Secretary.

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